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Exploring students' collaboration in computer-based inquiry settings

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Abstract

The use of Information and Communication Technology (ICT) in educational settings has received increased attention, and it is a common belief that ICT may enhance students' learning and provide productive learning environments.

This thesis is framed within the sociocultural perspective on learning, which view learning as an interactive meaning making process, where people learn when interacting with others and the artefacts in their surroundings. The overall focus of my thesis is to explore students' collaboration when engaging with a computer-based inquiry environment within the setting of school science. Studying collaboration gives access to a better understanding of the students' meaning making process, where they are working together with a variety of technology in the social practice of school.

The empirical data was collected during a design experiment as part of the SCY project. The development of the computer-based inquiry environment SCY-Lab is central in the project. The data collection took place in March 2010 at an upper secondary school located just outside Oslo. The students in the trial worked together in groups in order to design a CO2 friendly house. The main data material consists of video recordings of students' group activities as they engage with SCY-Lab. The conducted analysis followed the process of the two student groups Power Puff and Thumbs Up.

The analytical attention in this thesis is directed towards what characterizes the students' collaboration and how the computer environment, other digital resources and the institutional setting are functioning as structuring resources. The analysis of the students' interaction trajectory shows that the two groups differed in how they made decisions, what these decisions were based on, and how they discussed scientific concepts and phenomena. The two groups also differed in how they used the computer environment and digital resources. The students' orientations became more similar in the second last part of the project, as one of the groups orientation seemed to change towards being procedural. The findings are discussed in relation to the meaning of language in the students' collaboration and meaning making process, how the students comprehended and made use of the given technology in their collaboration and the situated and contextual features of the students' collaboration. Finally, I suggest some possible implications of my findings and how they can be seen in relation to challenges related to support of students' collaboration and design in CSCL.

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Contents

1 Introduction

The overall focus of this thesis is to explore students' collaboration when engaging with a computer-based inquiry environment within the setting of school.

In pace with the development of technology, our access to information has increased significantly and the ability to relate to, apply and remain critical to new information is now considered as crucial competencies. Moreover, the capacity to integrate different types of knowledge and skills through collaboration are seen as important skills. The demand for these new competencies has implications for the educational system (Ludvigsen & Mørch, 2009). Specifically, the use of Information and Communication Technology (ICT) in educational settings has received increased attention, based on a common belief that ICT may enhance students' learning and provide productive learning environments.

According to ITU Monitor (2009), the use of ICT has received increased focus in upper secondary schools in Norway since "Kunnskapsløftet". Also, 9 out of 10 students in upper secondary school experience that they have access to a computer when they need it (ITU Monitor, 2009). Related to this development, it is both interesting and necessary to explore how students learn with technology in school.

A large amount of research on the use of ICT in educational settings is concerned with inquiry learning in science education. The activities of scientific inquiry are seen as an idealized way of working with complex and meaningful problems, as they enhance the development of knowledge and skills needed in today's society. Scientific inquiry is based on processes and methods used by scientists, and are often related to activities such as orientation, stating hypotheses, experimentation, creating models and theories, and evaluation (van Joolingen, de Jong & Dimitrakopoulou, 2007). There is also a considerable focus on the importance of collaboration between students in the learning processes, and therefore collaborative scientific inquiry.

Consequently, a variety of computer-based inquiry environments has been developed with the purpose to engage students in collaborative scientific inquiry activities. The field of Computer-Supported Collaborative Learning (CSCL) is an emerging field within the learning sciences, concerned with how people can learn together with the help of computers. One of the main goals with CSCL is to create artefacts, activities and environments that enhance

learning (Stahl, Koschmann & Suthers, 2006). It is possible to separate the research within the field of CSCL into two main categories; the dialogical approach and the systemic approach (Arnseth & Ludvigsen, 2006). Many studies in the field of CSCL and on students' learning when engaging with computers have the individual as unit for analysis, and are focused on the final outcome of the learning situation (see for instance Kollar, Fischer & Slotta, 2007; Manlove, Lazonder & de Jong, 2006). However, this thesis is framed within the sociocultural perspective on learning, which sees learning as an interactive meaning making process, where individuals are interacting with mediating tools and artefacts in a social practice (Säljö, 2004). This perspective implies a focus on the process where the interaction and collaboration takes place, together with the mediating artefacts, such as technology, within the institutional setting of school. In order to study students' collaboration when engaging with a computer-based inquiry environment, a dialogical research approach will be applied as it makes the interaction, artefacts and institutional practices available for study (Arnseth & Ludvigsen, 2006).

One of the responses to the increased interest in the use of ICT in education and computer-based inquiry environments is the project called Science Created by You (SCY). The project has two main aims, which is to develop an innovative computer-based inquiry environment called SCY-Lab, and to gain further understanding of students' learning with computer-based inquiry environments. The research reported in this thesis is based on data material from students working collaboratively and engaging with SCY-Lab.

1.1 Research questions

The main aim with this thesis is to contribute to the understanding of students' collaboration as they engage with a computer-based inquiry environment in the institutional setting of school. My research questions also cover the aspects of how technology and digital tools, and the institutional setting are structuring the students' collaboration. I have chosen the following three research questions:

1. *What characterizes the students' collaboration as they engage with the computer-based inquiry environment SCY-Lab?*
2. *How is the computer environment, as well as other digital tools functioning as structuring resources in the students' collaboration?*

3. *How is the institutional setting functioning as a structuring resource for the students' collaboration?*

1.2 Thesis outline

The thesis consists of seven chapters. In the following, I will give an outline of the thesis and a short description of the content in each chapter.

Chapter 1- Introduction

The introduction provides background information, the focus of this thesis, research questions and thesis outline.

Chapter 2 – Theoretical perspectives

This chapter outlines the theoretical perspectives in this thesis, which is the sociocultural perspective. The sociocultural perspective view learning as an interactive meaning making process. According to this perspective, people are shaped by their participation in different activities and settings, and by how they use the different artefacts in their surroundings (Wertsch, 1991). Based on this view, this chapter will focus on the three aspects: interaction, artefacts and the social context.

Chapter 3 – Literature review

This chapter gives an overview of the field CSCL, with main focus on computer-based inquiry environments. Also, what can be seen as two main research approaches within the field of CSCL; the systemic and the dialogic (Arnseth & Ludvigsen, 2006) will be presented together with reviews of studies within both approaches. I will sum up the most important findings and give account for my analytical approach.

Chapter 4 – Empirical setting and methods

Here, I will present the empirical setting and the methods used in this thesis. The computer-based inquiry environment SCY-Lab will be described, together with the data material, analytical procedures and the selection of data material. Also, the quality of the conducted research will be discussed, with regards to validity, reliability, generalization, ethics, strength and weaknesses.

Chapter 5 – Analysis

In this chapter, I will analyse the interaction trajectory of the two student groups Power Puff and Thumbs Up, with focus on their collaboration, interaction and meaning making process. Excerpts from their project work will be presented, together with the setting. I will identify key points which I will return to in the discussion, and provide a summary of both groups.

Chapter 6 – Discussion

I will discuss the findings form my empirical study, focusing on the similarities and differences in the two groups' way of working collaboratively, in order to answer my research questions. The findings will be elucidated using theory presented earlier, together with relevant findings from the reviewed studies.

Chapter 7 – Implications and concluding remarks

Here, I will give a brief presentation of the conducted research in this thesis. Also, I will sketch some possible implications of my findings, and how they can be seen in relation to challenges related to support of students' collaboration and design in CSCL settings.

2 Theoretical perspectives

The sociocultural perspective view learning as an interactive meaning making process, where people learn when interacting with others and the artefacts in their surroundings. The meaning making process is present in all human activity. People are shaped by their participation in different activities and settings, and by how they use the different artefacts in their surroundings (Säljö, 2004). According to the sociocultural perspective one cannot understand learning without taking learners' interaction with each other, their interaction with cultural artefacts and the social context into account.

The concept of mediation is central within the sociocultural perspective, as individuals are interacting with the world with the help from both physical and psychological tools and artefacts (Säljö, 2004; Wertsch, 1991). In the following, I will focus on the three aspects mentioned above: interaction, artefacts and the social context. Firstly, I will say something about the meaning of language in the meaning making process. Vygotsky viewed language is as the "tool of tools" (Cole, 1994). It is in interaction with others that individuals negotiate and construct shared meaning, and language is seen as an essential mediating tool for this meaning making process. Secondly, I will go further into the concept of mediation and artefacts. In this part, the focus will be on material artefacts such as technology, as the students in my empirical study are interacting with technological tools in their meaning making process. Thirdly, I will discuss the situated and contextual related factors of the sociocultural perspective. Human actions are always part of, create and reconstruct the context. Actions are situated in social practices, and actions and practice constitutes each other (Säljö, 2004).

This implies that in order to study learning within a sociocultural perspective, it is essential to look where the interactive meaning making processes take place, along with the mediating tools and artefacts in the given social context. I will in this thesis have my focus on the students' collaboration as this gives access to a better understanding of the students' meaning making process, where they are working together with a variety of technology in the social practice of school.

I will conclude the theoretical chapter by sketching some theoretical implications for my empirical study.

2.1 Language and meaning making

Wertsch (1991) claims that mediational tools, such as language, emerge in concert with social forces. Within the sociocultural perspective, language is seen as the "tool of tools" for social interaction (Cole, 1994). This implies that the meaning making process is unfolding in social interaction, where language is an essential tool for communication between individuals.

Language is a mechanism to accumulate knowledge, insight and understanding for individuals. Language allows individuals to collect experiences and communicate and is according to Linell (1998) the most important mediating tool for interaction. Within the sociocultural perspective, language is seen as a bond between the individuals thought and its communication with the outside (Linell, 1998). Säljö (2004) points out three main functions of language within the sociocultural perspective: *an indicative function, a rhetorical function and a semiotic function.*

Language's *indicative function*, is the opportunity language gives to point to different objects and categories which are both present to us, and not. This function of language frees individuals from the present setting, and makes it possible to talk about more abstract phenomena's like past experiences, the future and feelings. Individuals are also able talk about other language phenomena, which makes it possible to discuss language at a meta-level (Säljö, 2004). *The rhetorical function* of language is according to Säljö (2004, pp. 92) to view language "as a living tool for meaning making between individuals acting in and through language within social practices." What it refers to is how an expression can be understood in several ways. Language is among many things a medium to influence people, and how they perceive the world. *The semiotic function* of language refers to its mediating power, and the flexible relation between expressions and the phenomena they refer to. The relation between the expression and what is being described is seen as symbolic, or to be of semiotic character. Linguistic expressions also express meaning and content, in addition to phenomena (Säljö, 2004). The meanings attached to words and expressions are dependent on both the communicative situation and contextual factors. This way, due to the semiotic power of human language, it does not provide a neutral picture of the world around us. Attitudes, values and stances are integrated parts of language, and are not always visible. The use of language in everyday interaction is not based on dictionary definitions, and language cannot be seen as exchanging messages with a fixed and neutral meaning. Individuals are creative and adjust their communication to fit different settings and contexts. According to Linell

(1998), the meaning of a communicative act does not exist on beforehand. The meaning is negotiated, constructed and developed as an achievement of those interacting. Language is both individual and collective, and because of this, it functions as a link between culture, interaction and the thinking of the individual. According to Säljö (2004), how individuals acquire content and meaning, and how the interplay between what words mean to individuals and a collective are important questions within the sociocultural perspective.

The semiotic function of language is the one of most interest in this thesis, as the focus of my study is students working collaboratively with a given project, using mediating tools such as technology. The students are adjusting their communication to the institutional setting of school, as they are negotiating a shared meaning of scientific words and concepts. The meaning of these scientific words and concepts are dependent on both the communicative situation and the contextual situation.

Within the sociocultural perspective, learning is seen as a meaning making process that unfolds in interaction between individuals, in concert with mediating artefacts and the contextual setting. Therefore, it is essential for my inquiry to focus on the students' collaboration as this gives access to a better understanding of the students' meaning making process. In the following, I will take a closer look at sense making and collaboration.

2.1.1 Sense making and collaboration

As we have seen, it is in interaction with others that individuals are interacting and making sense of words and concepts, and negotiating a shared meaning, according to the sociocultural perspective. Therefore, it is central to study collaboration as this is potential setting for joint sense making, and as it gives access to and a better understanding of the students' meaning making process.

According to Linell (1998) structures in discourse are shaped through the collaboration of the people interacting. Those interacting are guiding each other through the dialogue, and structuring and shaping it. The development of topics and conversation turns is a joint activity where the participants are developing and negotiating meaning, and are finding, changing and closing topics together. Collaborating in dialogue, where the participants borrow words from each other, and finish each other's sentences help them to demonstrate a shared experience

and meaning. The situation opens up for disagreements, differences and shared interpretations of the topic being discussed.

Lemke (1990, pp. 1) presents what he calls learning science, which also means "learning to use specialized conceptual language in reading and writing, in reasoning and problem solving, and in guiding practical action in the laboratory and in daily life." Lemke's focus is how people use the specialized language of science to make sense of the world, and to make sense of and to one another.

As argued above, language has a semiotic function (Säljö, 2004). Words and expression does not necessarily have a fixed meaning, they can hold several different meanings. Lemke (1990) claims that a word in isolation only has a "meaning potential", which implies that it can contain a range of possible uses and mean various things. It is in the actual communication that more exact meanings and interpretations are negotiated by the interlocutors and used for the needed purposes (Wertsch, 1991). In other words, the meaning potential is created in collaboration between individuals. According to Säljö (2004), thinking is a collective activity as well as being individual, it can unfold both in the individual as well as in a social context where participants are thinking together in order to solve a task or a problem. Individuals in interaction are negotiating a shared meaning which is in line with the situation and context (Säljö, 2004). Related to this is the thought that "the word in language is half someone else's", and that individuals interacting "appropriate other's words" (Wertsch, 1991, pp. 59). Interlocutors are dependent on others, finding others utterances relevant and making them their own (Linell, 1998). Students working with scientific concepts in a school setting are negotiating shared meaning which is related to the context they are participating in. The concepts are not necessarily ascribed the meaning that was intended by those who gave them the task, or the meaning from a dictionary. The meaning of the concepts and how these meanings are applied is constructed in concert with the participants, the mediating tools available and the context which they are operating in.

However, this does not mean that students are free to come up with any interpretation of a subject. Within the field of science, there are normative ways of talking about a concept, which is seen as valid. When combining words, the meaning becomes more than just the separated parts. It is not enough just understanding the meaning of each word; one needs to know the relations of meaning between the words (Lemke, 1990). Lemke calls the pattern of connections among the meanings of words in a particular field of science a "thematic pattern",

which is according to him part of the common ways of speaking about a subject, which we have heard, read and used countless times in speech and in writing. Lemke's (1990) definition of thematic patterns is as follows:

> [..] a pattern of semantic relationships that describes the thematic content, the science content, of a particular topic area. It is like a network of relationships among the scientific concepts in a field, bud described semantically, in terms of how language is used in that field. There is science in the dialogue exactly to the extent that the semantic relationships and the thematic pattern built up by the dialogue reproduce the thematic pattern of language use in some field of science (pp.34-35).

This can also be seen in relation to what Wertsch (1991, pp. 39) refers to as decontextualized mediational means, which related to scientific concepts means that they are treated as abstract objects of reflection, rather than embedded in the context. For instance, this implies that the students working with SCY negotiate their own meaning of the scientific concepts they are presented with, as we will see in the following.

Vygotsky make a distinction between "sense" and "meaning" (Säljö, 2004, pp. 89). This distinction is capturing some of the same duality as described above. With "sense" he means the local meaning words and concepts are given in the concrete practice. And with "meaning" he means the normative meaning, found for instance in the dictionary. Using this distinction, one can say that the students working with SCY are trying to make sense of the scientific concepts which are presented to them. These concepts come with a meaning, but it is up to the students to make sense of them. One can say that there is a tension between the normative version of a word or concept, and the meaning it is ascribed in a given context (Säljö, 2004). Seen in relation to scientific concepts central in the SCY project, like emissions, heat loss and CO2 may not mean the same to the students as the teacher. The students working in groups may have a notion of the authorized versions of the concepts used, but they will still negotiate a shared meaning within the group which is relevant for the context and the available tools.

Participants interacting is according to Linell (1998) constantly testing their mutual understanding and adjusting to each other. Linell (1998) argues that communication does not necessarily produce a total "sharedness" of meaning, but rather "attempts to expose and test their understandings". Within the sociocultural perspective, knowledge is closely linked to argumentation and action within social practices. Knowledge is produced and reproduced

within social practices, and cannot be understood as something neutral. Individuals are trying to see, understand and deal with the world in a certain way (Säljö, 2004).

The value of collaboration can also be seen in relation to the development of performance of the individual. Related to this is Vygotsky's (1978) notion of the "zone of proximal development", which is defined as:

> [...] the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (pp.86)

This is the distance between the level of performance an individual is capable of on its own, and what he or she could accomplish when guided by someone more capable (Campione, Brown, Ferrara & Bryant, 1984). This is also a reason to focus on students' collaboration, as development and understanding of scientific concepts and phenomena may occur in situations where students collaborate. And by studying students' collaboration, the understanding and development may become visible.

As we have seen, language is seen as "the tool of tools" within the sociocultural perspective Cole (1994). Individuals are interacting and making sense of words and concepts, and negotiating a shared meaning. Although language is an essential mediating artefact, humans are surrounded by physical tools and artefacts in everyday life. These artefacts are also crucial parts of the meaning making process.

2.2 Mediation, artefacts and meaning making

According to the sociocultural perspective, mediating artefacts such as technology are seen as crucial parts of the students' meaning making process. In this part of the thesis, I will discuss the importance of mediation and artefacts for the meaning making process, within the sociocultural perspective.

Mediation is essential within the sociocultural perspective, and the term suggests that individuals are not in direct and uninterpreted contact with the world (Säljö, 2004). We are interacting with the world around us with the help from both physical and psychological tools, as they are integrated parts of our social practice. Wertsch (1991, pp. 12) uses the term

"mediational means" to describe tools and artefacts that shapes human action. Human thought, action and ways of viewing the world can be seen as a result and part of our culture and physical and psychological tools. Säljö (2004) refers to Leontiev (1981) when he points out that human knowledge and conventions are embedded in the artefacts in our surroundings. Both humans and artefacts are parts of a dynamic culture where tools and artefacts are constantly developed together with expectations concerning what humans are capable of. This is a central aspect of the sociocultural perspective: in order to understand learning as a social activity, one has to take both the mediating artefacts and the social aspects into account. These cannot be understood without each other.

Human behaviour is related to artefacts and tools in several ways. As mentioned above, Säljö (2004) points out two aspects of artefacts: human knowledge and conventions are embedded in them, and they make us able to perform tasks that would not be possible without them. Cole (1994) describes this double side of artefacts as their "dual nature", and claims that artefacts are simultaneously ideal (conceptual) and material:

> They are ideal in that they contain in coded form the interactions that they mediated in the past that they mediate in the present. [..] They are material in that they are embodied in material artefacts (pp.80).

A medicine student practicing surgery using a simulator is an example of how tools can make people able to perform tasks that would not be possible without. Related to my study, the students working with SCY are able to change the different material for their house, experiment with house designs and to see how it affects heat loss and emissions, among other things. This is tasks that would take much effort in real life.

The idea that words only have a meaning potential (Lemke, 1990) can be seen in relation to artefacts as well. Students working with technology when learning science, like the students working with SCY to design a CO2 friendly house, are faced with the challenge it is to negotiate and create a shared meaning of the tool they are dealing with. It is not given that the students use the technology like intended by the teacher or designer. It is in the interaction that artefacts become mediational means, as well as they shape the action in essential ways (Wertsch, 1991). This implies that the use and meaning of the artefact is created, negotiated and reconstructed by the individuals in the interaction. An artefact can serve several purposes and hold a different meaning from context to context. The meaning is constantly negotiated

by the participants during interaction, and the mediating artefacts are a part of this meaning making process.

At the same time as artefacts, such as technology, have a meaning potential, they also provide students with a structure. Säljö (2004) refers to Lave (1988) claiming that structuring resources may guide individuals to understand how things can be done within different practices. In other words, the structuring resources are part of the meaning making process. That resources can be seen as structuring for individuals actions or sense making, does not necessarily imply that they constitute positive or productive actions. One can say that structuring resources can provide both positive and negative outcomes, however, how they become structuring is an empirical question. As claimed earlier, the potentials are realized in the settings they are used.

Computer based learning environments does function as a structuring resource for students working with scientific concepts. This can be seen in relation to the students working with SCY, where there is a structure within the technology, which the students are interacting with. The structure may give them clues or directions on what to be done, and what is expected of them (Furberg, 2009). Although they are given this structure, the students still have to make sense of the task.

We have seen that mediation, and both intellectual and physical tools are central within the sociocultural perspective way of viewing learning as meaning making. However, the social practice where individuals interact is also essential in understanding learning as a meaning making process.

2.3 Situated and contextual factors in meaning making

Students' meaning making activities does not happen in a vacuum. Their activities are always situated within a social and institutional context: the school setting. The students in my study are negotiating a shared meaning in interaction with each other and with a variety of technological tools. According to a sociocultural perspective this context is a central part of the students' meaning making process, as they are negotiating and making sense of its expectations, norms and values. Thus, in order to understand their process of meaning making, it is essential to take the social context into account.

Säljö (2004) states that human actions are situated in social practices and that actions and practice constitutes each other. Individuals ascribe a meaning to a context and regulate actions accordingly, based on assumptions of what is expected in that given context. This implies that knowledge and competencies are not just isolated units, but individuals also have to be able to decide when a certain kind of knowledge is appropriate or useful, and how it functions in different contexts. In other words, there is a relation between knowledge and context which has to be interpreted and created by the individual. This relation is not fixed, but varies from practice to practice.

Students working with science in school not only have to make sense of scientific concepts and words, they also have to interpret and make sense of the social context, expectations and norms, and they have to decide how to respond to these expectations and norms (Furberg, 2009; Furberg & Ludvigsen, 2007). The students working with SCY had to make sense of the technology and the scientific concepts together with the social practice within the school context. This context includes many factors such as teachers, fellow students, values, norms and expectations. It does not mean that the context can be used to explain actions and interaction, or that individuals are affected by the context. On the other hand, within the sociocultural perspective, actions and interpretations are part of the context. This is because human actions are part of, creates and recreates the context. Säljö (2004, pp. 138) refers to Bateson (1973) when he points out that all communication presupposes a context in order to be understandable, or to make sense. The context is a part of what gives an utterance a specific meaning. The comprehension of contexts and their expectations that come with them help individuals to plan and adjust thoughts and actions. To gain insight into the link between context and how to interpret the communication from others is according a subtle learning process, especially in our knowledge-intensive society. Schools have a historical context with a long communicative tradition, where it can be difficult to change the existing practices of how one is to interact (Wells, 1999; Säljö, 2004)

Wertsch (1991) uses the term “privileging” to explain when one mediational mean is regarded as more appropriate or effective than others, in a particular social context. Privileging is dynamic, as there is a “dynamic negotiation involved”, and the participants in different settings often have the opportunity to define the situation in creative ways. Wertsch (2004) argues that there is an underlying assumption that one shall not introduce information or topics from the outside world in classroom settings, unless one is told to do so. He describes

this as: "..an invisible barrier has been placed round the topical "space" that is eligible for discussion" Wertsch (2004, pp.127). In other words, not all contributions are appreciated to the same extent in the classroom (Ludvigsen, in press). This can be said about others contexts as well, but the school context is interesting in this thesis.

The notion of privileging can be seen in relation to the earlier mentioned concept thematic patterns (Lemke, 1990) and normative ways of talking about a subject. This implies that some ways of talking about scientific concepts or a science incident are considered as more valid or correct than others in the institutional setting of school. This can be seen in relation to the thought that students need to decide how to respond to the social context with its expectations and norms. The response may include choosing ways of talking that is appropriate. As mentioned above, gaining insight into the link between context and communication, and how to interpret these are subtle in students' learning process (Säljö, 2004). The teacher's role may play an important part here, as the students have to make sense of what the teacher says, together with the others factors mentioned.

Related to this, one can say that the context with its norms, values and practices also may function as structuring resources, as the students are making sense of the practice within the school context. However, the norms, values and practices embedded in a context are not necessarily visible or expressed explicitly. This way, it is up to the students to interpret and make sense of how to act and relate to the given context. In relation to my study, one can say that the students working with SCY have to make sense of and interpret the technology, the given task, expectations and the messages and signals given by the teacher.

Jiménez-Aleixandre, Bugallo Rodríguez and Duschl (2000) makes a distinction between the activity of "doing school" and "doing science" which is useful in clarifying a sociocultural approach to the meaning making process done by students. This distinction points at what they regard as two types of student activities when students are working with science in the school setting. "Doing school" refers to the social habits of life in the classroom, or actions or activities that form the routines and rituals in school (Jiménez-Aleixandre et al., 2000, pp. 758; Furberg, 2010, pp. 17). "Doing science" refers to students "construction, representation, and evaluation of knowledge claims and investigative methods", or their scientific argumentation (Jiménez-Aleixandre et al., 2000, pp. 759). The activity of "doing school" is according to Jiménez-Aleixandre et al. (2000) often taken for granted and become obstacles

for the activity of "doing science", as it is seen as an unnecessary activity which needs to be reduced.

Furberg (2010) argues that it is of equal importance to focus on both the activity of "doing school" and the activity of "doing science". Taking both types of actions into account entails an equal focus on both the social interaction, as well as on "how specific ways of acting and using mediational means have developed historically and culturally" (Furberg, 2010, pp. 17). In other words, both the students' activities of "doing school" and "doing science" presented by Jiménez-Aleixandre et al. (2000) needs to be taken into account when understanding their meaning making process.

The contextual features need to be examined together with the social interaction, in order to understand the meaning making process. In relation to my empirical study, this implies that it is central to focus on how the students invoke and address the institutional practices, norms and expectations when studying students' collaboration.

2.4 Theoretical implications for my empirical study

In this part of the thesis, I have given account for learning seen within the sociocultural perspective as a meaning making process. I have focused on three aspects that, according to a sociocultural perspective are important elements of students' meaning making process. These three aspects are interaction, artefacts and the social context.

As discussed, learning within the sociocultural perspective is seen as a socially organized activity where individuals interact and negotiate shared meaning, engaging with mediating artefacts, both physical and intellectual in a social setting. In other words, the process of meaning making unfolds in social interaction, or in collaboration, within a given context. I will focus on collaboration between students in this thesis, and in order to do so, the unit of my analysis will be the actual interaction between the students engaging with a variety of technological tools in the institutional setting of school.

3 Literature Review

In the following, I will present the field of Computer-Supported Collaborative Learning (CSCL) with main focus on computer-based inquiry environments, since SCY-lab is such an environment. There are two main research approaches within the field of CSCL; the systemic and the dialogic (Arnseth & Ludvigsen, 2006). I will present the two approaches, review studies within both and sum up the most important findings. Also, I will give account for my analytical approach.

3.1 About CSCL

Computer-supported collaborative learning (CSCL) is a relatively new and emerging field within the learning sciences. The field appeared in 1990 as a reaction to software that forced students to learn as isolated individuals (Stahl et al. 2006). CSCL provided a shift in perspectives on learning and cognition. Ludvigsen and Mørch (2009) argue that this was to some extent a result of the raised expectations in a knowledge-based society. The field of CSCL is concerned with how people can learn together with the help of computers; both co-located and distributed, and understanding actions and activities meditated by Information and Communication Technology (ICT) (Ludvigsen & Mørch 2009; Stahl et al. 2006). The research questions addressed in CSCL covers different aspects, like how small groups interact and develop shared meanings over time and how opportunities for learning change, among others (Ludvigsen & Mørch, 2009).

Ludvigsen and Mørch (2009) argue that the society to a large extent require new types of knowledge and knowledge advancement, and as a consequence, new models of education. Some normative assumptions of the importance of CSCL include that the field is concerned with teaching and learning the knowledge and skills that are required in our knowledge-based society. These skills are domain specific knowledge and the ability to work in teams, among others (Ludvigsen & Mørch, 2009).

3.1.1 Development of CSCL environments

A shared goal within the field of CSCL is according to Stahl et al. (2006) to create artefacts, activities and environments that enhance the practices of group meaning making. Within the

field, there are an amount of researchers working with designing learning environments which are intended to enhance learning. This research is concerned with different types of environments, and has different focus. In relation to my empirical study, I will have my main focus with the CSCL environments which is concerned with scientific inquiry, since SCY-lab is such an environment. Quintana et al. (2004) refers to Blumenfeld, Fishman, Krajcik, Marx, and Soloway (2000), Bransford, Brown, and Cocking (2000) and Linn (2000) when they claim that recent educational approaches emphasize more ambitious learning environments, where learners engage in inquiry to develop knowledge and skills when investigating meaningful problems. Quintana et al. (2004, pp. 341) describe the process of inquiry as posing questions and investigating them with empirical data, and argues that this concept is representative of ambitious learning as the phases are general to several disciplines.

Scientific inquiry is seen as an idealized way of working with complex and meaningful problems, as it enables learners to develop knowledge and skills needed in the society of today. Several computer-based environments are based the idea of knowledge building and scientific inquiry, such as CSILE, WebCSILE, Knowledge Forum, Future Learning Environment, CoLAB, WISE and SCY-Lab, among others (Ludvigsen & Mørch, 2009; Kollar et al. 2007; de Jong et al., 2010). Many of the environments mentioned provide students with an open problem space, where students are relatively free in order to decide what activities to engage in, and how to do so (Kollar et al., 2007).

Within the field of CSCL, there is also an amount of research concerning how these environments are being used and how they affect students' learning activities. Stahl et al. (2006) points out the following concerning research within CSCL:

> [..] it is important to view CSCL as vision of what can be done by the help of computers and what kind of research to be conducted, and not as an established body of broadly accepted practices (pp.1).

The research conducted within the field of CSCL, and the methods used, are relevant for my empirical study, especially with focus on the use of computer-based inquiry environments. Therefore, I will in the following present two mainstream research approaches within the CSCL field, discuss their differences as well as position my own study according to these two approaches.

3.2 Research approaches within CSCL

According to Arnseth and Ludvigsen (2006) it is possible to divide the CSCL research into two main categories; the systemic and the dialogical approach. The two approaches differ from each other when it comes to research methodology and analytic practices, and the distinction makes it possible to give a more holistic picture of research within the CSCL field (Arnseth & Ludvigsen, 2006; Ludvigsen & Mørch, 2009). Also, this distinction shows how the two approaches have different focus; the dialogic approach is concerned with the process where the interaction takes place with the artefacts, while the systemic approach is concerned with the individual cognitive processes and the effects of an intervention.

3.2.1 The systemic approach

Within the systemic approach, the analytic purpose is to identify interdependencies between quantifiable variables. This also includes how particular technological features facilitate students' understanding or ability to problem solving (Arnseth & Ludvigsen, 2006). Arnseth and Ludvigsen describe the results of the analytic practice as following:

> The result of the analytical practice is the formulation of a model, or readjustments of a previous model, which specifies the correlations between the variables that were defined at the outset and inscribed into the analytical scheme employed (pp. 170-171)

Such a model may say that a CSCL application together with a certain practice, are likely to produce a positive learning outcome (Arnseth & Ludvigsen, 2006). The unit for analysis is the individual and processes like internalization and transfer (Ludvigsen & Mørch 2009). The researcher often operates with predefined models of the individual's actions, and aims to measure to which extent these models are realized. An example of such predefined models may be taken from Kollar et al. (2007) and their scripts, or models of collaboration, where the students in their study was classified according to their procedural knowledge about collaboration. Another example is Hakkarainen's (2003) model of progressive inquiry, which is based on the view that students' learning processes should be similar to that of a researcher, and consists of explanatory knowledge in contrast to merely factual knowledge (Furberg & Ludvigsen, 2008).

Studies within the systemic approach often employ pre- and post-tests in order to measure effects, experimental designs and the use of predefined categories. Within this approach, the

institutional setting is seen as something that surrounds, constrains or facilitates activities. The actions of the students are often detached from the institutional settings and not taken into account in the analysis (Arnseth & Ludvigsen, 2006). This is in contrast to the dialogical approach, which I will present in the following.

3.2.2 The dialogic approach

Within the dialogical approach, the unit of analysis is often the interaction taking place between individuals. A dialogical approach implies that learning is seen as a socially organized activity, and is influenced by research done within the situated learning and sociocultural perspectives (Ludvigsen & Mørch, 2009).

The analytic practice within the dialogic approach is concerned with the sequential unfolding of activities along different time scales (Lemke, 2000). It is in the social interaction the meanings and effects of CSCL tools become available for study (Arnseth & Ludvigsen, 2006). Arnseth and Ludvigsen summarize the focus of the dialogic approach as follows:

> (..) the aim is not to understand how different variables covariate, but rather to understand how the meaning of *knowing*, *knowledge* and *artifacts* is constituted in dialogue between participants, who through their actions are responding to various contextual features of the setting and are thereby making them relevant (2006, pp.172)

By using the dialogic approach when studying CSCL environments, and more specific, computer-based inquiry environments, it is possible to examine how the process of meaning making is unfolding over time. Research on the field show that the effectiveness of CSCL tools is closely related to social and cultural aspects where they are introduced, this implies that it is important to take the institutional context into account (Arnseth & Ludvigsen, 2006).

According to Arnseth and Ludvigsen (2006), combining the systemic and the dialogical approach is not easy, as they are quite different when it comes to analytical practices. However, we can learn from both types of studies. They are both needed within the CSCL field, but they are useful for different purposes as they make different aspects of CSCL activities available for study (Arnseth & Ludvigsen, 2006). In order to study collaborative inquiry in CSCL settings and in relation to the focus of my study, my argument is that the dialogical approach is the most fruitful, as it takes the institutional factors into account together with mediating artefacts and interaction.

3.3 Review

I will in the following do a review of studies conducted within both approaches with focus on students' collaborative inquiry learning in CSCL environments, in order to point out important findings across different technologies. I will start with three systemic studies, and follow up with three dialogical studies focusing on their aims, the methods used and the presented findings. There are three main reasons for selecting these particular studies. Firstly, the three following studies focus on different computer-based inquiry environments. Secondly, the findings from the studies represent robust and coherent findings within the field. Thirdly, they exemplify some of the general differences between a systemic and dialogic research approach. Altogether, this makes the studies relevant for my empirical study, and is also helping to clarify why I have chosen a dialogical approach for my analysis.

After the review of the studies from both approaches, I will sum up the most important findings. Finally, I will give account for my analytical approach, which is the dialogical perspective, and explain why this approach is the most fruitful for my empirical study.

3.3.1 Studies within the systemic approach

In the following, I will do a review of three studies within the systemic approach: Kollar et al. (2007), Bell and Linn (2000) and Manlove et al. (2006). The three studies are concerned with how to design learning environments in order to support collaboration, and they present robust findings within the field. I will present their focus, methods and findings.

Supporting collaboration with collaboration scripts

Kollar et al. (2007) investigate in their study how external scripts with different structure interact with students' internal scripts, with respect to individuals' acquisition of argumentation skills and of domain-specific knowledge in a Web-based learning environment called "Web-based Inquiry Science Environment" (WISE). The students were given a rather open problem space, and worked in dyads with a task called "The Deformed Frogs Mystery", where the students were provided with two competing hypotheses to be discussed based on various sources of information.

Ninety students from two secondary schools participated in the study, and two versions of an external collaboration script were embedded in the learning environment. These collaboration

scripts can be described as idealized models of collaboration. The external scripts were both high and low structured, which means that they were giving various support and guidance accordingly, as the students in the study were holding differently structured internal scripts. This structure was classified as high or low by having the students answer a pre-test assessing their internal scripts. The study was conducted in two sessions. The students completed questionnaires on demographic variables, prior domain-specific knowledge and collaboration, and computer experience. They worked in dyads collaborating on the given task, and immediately after completed questionnaires assessing their argumentation skills and domain-specific knowledge. The researchers scored the responses from the students and used them for analysis, in relation to the set of parameters for the level of reasoning skills and knowledge skills.

One of the main findings reported the authors suggest that the script that gave high degree of collaboration support (high structured external collaboration script) supported acquisition of argumentation skills of all learners, regardless of their internal scripts. But, the high structured external script did not support the acquisition of domain-specific content knowledge. In others words, the students who received a high degree of support and guidance on collaboration scored higher on collaboration skills, than those who did not receive the same support, regardless of their already defined skills in collaboration. On the other hand, the high degree of collaboration support did not support the conceptual knowledge. Thus, the findings add to the large body of research that shows the relevance of supporting students' collaboration by explicitly prompting them in their process of collaboration. But, the students did not gain more conceptual knowledge. As we will see later, these findings match with those of Krange and Ludvigsen (2008).

Supporting collaboration by self regulation

Another study that shows the importance of supporting students' collaboration, is a study performed by Manlove et al. (2006). The authors aimed to examine the potentials of online tool support for regulation during collaborative learning, and to see if it promotes student learning. In order to investigate this, they conducted a study with sixty-one high-school students who worked together in small groups to conduct a scientific inquiry with fluid dynamics, using randomized group design with two conditions. The students were to solve the task using the learning environment Co-Lab, which is a collaborative discovery learning

environment, where students can experiment through simulations. All students were given a support tool called Process Coordinator (PC) to regulate their activity, but only the students in the experimental condition was given the PC tool with embedded regulative directions (PC+). Thus, the students in the control condition were given the PC tool, but without regulative directions (PC-). Students in the PC+ groups were expected to achieve higher learning outcomes and produce more instances of planning, monitoring and evaluating than PC- groups.

Students' learning outcomes were indicated by the quality of the groups' final model solutions. In order to evaluate this, the authors assessed the number of correctly specified variables and relations in the models created by the students. Analyses of the students' learning activities focused on the use of the PC tool and verbal interaction. The students' use of the PC tool was scored from the log files, with focus on actions concerning planning, monitoring and evaluation. Verbal interaction was scored from the chat history files, and segmented messages into utterances. An utterance was then classified according to its function in the dialogue: cognitive, regulative, affective, procedural, and off-task. Conceptually related utterances were grouped into episodes: regulation of collaboration (RC) and regulation of the learning task (RTL). The researchers also did qualitative analyses of the chat files.

The results suggest that PC+ groups on average achieved significantly higher model quality scores than PC- groups. In other words, the students who received regulative directions showed better learning outcomes, than those who did not. They also used the PC tool for planning purposes more often than PC- groups did. The latter difference arose according to the authors because the PC+ groups consulted the PC frequently in the early stages of the task. Students in the PC+ group used the PC for monitoring purposes just as often as their PC- counterparts did. The regulative guidelines within the PC+ tool did not lead to higher instances of learning activities such as monitoring and evaluating.

The students in the study with access to regulative instructions performed increased planning activities, which is one of the regulative activities students should engage in while doing inquiry learning, according to the authors. The authors conclude with stating that the study overall indicate that giving students regulative guidelines during collaborative inquiry has positive effects. Thus, this study also shows the importance of supporting students in their collaboration.

Supporting collaboration with arguments as learning artefacts

The study by Bell and Linn (2000) are concerned with the topic of working together in order to construct arguments and enhance the understanding of science. They explored in their study how students' working in pairs construct arguments, and the relationship between students' views of the nature of science and argument construction. The students in the study are working with the Knowledge Integration Environment (KIE) debate projects, which was designed to take advantage of internet resources and promote student understanding of science. The KIE environment also consisted of an argument building software called SenseMaker meant to "make thinking visible", and a guidance component called Mildred meant to support autonomy and reflection.

The authors studied middle school students working in pairs, exploring the topic of light by doing experiments involving the collection and analysis of real-time data. The project was called "How far does light go?" which asked them to link existing and new ideas. The students spend six days reviewing evidence and constructing their SenseMaker arguments. Arguments included explanations relating individual contributions of evidence to the debate and categorizing the evidence into theoretical frames. Students could choose from existing frames, and they could create new ones.

The explanations provided by the students were coded by argument characteristics and student actions in KIE were logged and time-stamped. The students also completed a survey which investigated their beliefs about the nature of science, distinguishing between beliefs about scientific process and beliefs about learning strategies.

The results of the study suggest that the activities implemented in the project elicit knowledge integration that goes beyond the instructed structure and motivates students to restructure their ideas in unique ways. They also found that the students engaged in a productive scientific inquiry during the project. Furthermore, engaging students in knowledge integration and argument construction enhances their understanding of the nature of science.

The three reviewed studies within the systemic approach have showed both the importance of supporting students' collaboration, and that supporting students in the joint construction of arguments and "thinking together" may enhance their understanding of the nature of science.

3.3.2 Studies within the dialogic approach

In the following, I will do a review of three dialogical studies: Krange and Ludvigsen (2008), Furberg and Ludvigsen (2008) and Mercer, Dawes, Wegerif and Sams (2004). The three studies are concerned with students' meaning making processes in collaborative settings, with focus on the institutional aspects and how talk can be used as a tool for joint reasoning and development of science understanding. They too present robust findings within the field. I will present their focus, methods and findings.

Institutional aspects of students' procedural and conceptual understanding

In a study Krange and Ludvigsen (2008) focus on the relationship between procedural and conceptual problem solving in a computer-based 3D model supported by a website. In order to do so, the authors analyzed how students' interactions are mediated by the school as curriculum deliverer, the knowledge domain and the computer tool. The study was conducted as a design experiment, which implies that the researchers designed a new type of educational environment, introduced this into an everyday school setting and carried out studies of how the students' knowledge constructions was mediated by these, in this particular situation. The collected data material consisted of video of the students' and teachers interaction via the learning environment (they were geographically separated) and use of the computer tool and video recordings of a face-to-face debriefing session, with a focus on interactional data. The analysis was empirically driven, and the researchers used interaction analysis when analyzing the data. This means that talk and actions are main focus, together with how these unfolds and evolve moment-to-moment within a contextual setting.

The authors found that procedural types of problem solving tend to dominate the students' interactions. Conceptual knowledge construction was present only where it was necessary in order to carry out the problem solving. The students were first of all focused on solving the given problem and least focused on understanding the knowledge domain. But, when they leave the problem-solving mode, they spend more time discussing the knowledge on a deeper level. The authors claim that school as a curriculum deliverer partly hindered than stimulated the students' knowledge making in science education. The authors argues that even though the students solved the task they were given, it does not mean that they have understood the knowledge domain, or that they are able to see the concepts as parts of a larger system. They also found that the teacher's role is important. They argue that the teacher in this study could

have contributed to improve the students' capability to consider conceptual elements of the given task.

Institutional aspects of meaning-making in computer mediated settings

Another study that address the institutional aspects of students' meaning making processes in collaboration setting, where students engage with web-based inquiry environments, are a study performed by Furberg and Ludvigsen (2008). The aim of the study is to examine students' meaning-making of socio-scientific issues in ICT-mediated argumentation settings.

The study is based on an analysis of students working with a web-based groupware system called Future Learning Environments 2 (FLE2), concerned with genetics. This environment consists of various tools to support progressive inquiry, which is a model based on the view of seeing students' learning processes as a research activity. In the study, the authors focus on the interaction trajectory of two students, and the main data material consisted of video recordings of the students' interactions and activity.

The authors found that the two students had different orientations when trying to understand and solve the task, and that this difference contributed to an ambivalent tension. Their orientations were directed towards "fact-finding", finding scientific explanations and exploring the ethical and social consequences. The tension which was found contributed to productivity in that sense that it urged the students into discussion and meaning making, but it also showed that collaborative learning can be challenging and complex. Also, the students' orientations changed during the learning sequence. The students went from being concerned with understanding the knowledge domain and providing explanations, to a changed orientation towards the procedural aspects, such as completing the final product. The authors argue that it is the institutional norms, expectations and values that change this orientation. Thus, the authors argue that in order to gain a deeper understanding of students' meaning-making of socio-scientific issues in ICT-mediated settings, it is important to be sensitive to how they orient their talk and activity towards the norms, expectations, values and demands embedded in the educational setting.

Using language to learn science

The study conducted by Mercer et al. (2004) is interesting in relation to this thesis as they investigate the validity of sociocultural claims. These claims concern how students' learning of science is a discursive process, and that interaction with partners while carrying out scientific investigations is beneficial for learning and understanding. It also concerns how scientific concepts and ways of reasoning can be learned through participation in social interaction as well as individualized activity.

An intervention program was designed, called "Thinking Together", which was built upon earlier research. This research showed that the induction of children into what Mercer et al. (2004) call "exploratory talk", which is an explicit, collaborative style of reasoning, led to gains in children's individual scores on a test of non-verbal reasoning. The aim with the study was to consider to what extent the children were using language appropriately and effectively as a tool for thinking together.

Seven classes of children aged 9-10 were designated "target classes", and a matched set of control classes in similar schools was identified. The teachers in the study were provided with a detailed lesson plan, where each of these lessons applied a specific talk skill and targeted a specific concept in science. Some of the lessons involved computer-based activities. The data material consisted of video recordings, audio recordings among others. The authors used qualitative and quantitative methods in order to investigate changes in the quality of children's talk and joint reasoning. In order to consider the quality of the talk, the features of exploratory talk was used as point of reference. They made comparisons between the talk of the children in target classes and control classes, together with comparisons between the pre-intervention and post-intervention of children in target classes.

The results from the study indicate that children can be supported in order to use talk more effectively as a tool for reasoning, and that activities based on talk can function as support for the development of reasoning and scientific understanding. The authors conclude in their study that their results support the claim that language-based, social interaction is a developmental influence on individual thinking, together with support for other claims within the sociocultural perspective on education. They argue that their findings add to the evidence that the development of scientific understanding is best supported by a combination of peer group interaction and expert guidance. The latter can be seen in relation to the claim provided by Krange and Ludvigsen (2008) regarding how the teacher in their study could have

contributed to improve the students' capability to consider conceptual elements of the given task.

3.3.3 Summary of the reviews

I have now done a review of six studies where the three first studies can be characterized as systemic, and the three latter as dialogical.

In order to sum up, their findings show to explicitly support students' collaboration contributes to enhance their collaboration skills. However, the student does not necessarily gain deeper understanding of the knowledge domain, and they are mostly procedurally oriented. We have seen the importance of taking the institutional setting into account when studying students working with CSCL tools, in order to gain further insight and understanding of how they make sense and meaning of the scientific concepts and the context. Also, the teacher plays an important role, as students' scientific understanding can be supported by expert guidance.

Altogether, it is important and constructive to study students working with computer-based inquiry environments in order to gain further insight and understanding of the field. Increased insight and understanding can give important implications for further design and redesign on learning environments.

3.4 The analytical approach in this thesis

In the following, I will give account for my analytical approach, which is the dialogical perspective, and explain why this approach is the most fruitful for my empirical study.

Research within the field of CSCL report both positive and negative findings when it comes to the impact of CSCL tools. The negative findings within CSCL research are not necessarily due to the nature of CSCL tools. To fully understand CSCL, it needs to be examined in relation to the context they are used (Arnseth & Ludvigsen, 2006). Several studies have shown that different types of CSCL tools under certain conditions can be part of practices that produce more effective and productive learning outcomes. Arnseth and Ludvigsen (2006) refer among others to Hoadley and Linn (2000) and Cohen and Scardamalia (1998) when mentioning how CSCL were reported to facilitate students' reasoning and argumentation, and

task orientation and reflective activity. On the other hand, there are also reported disadvantages with CSCL. Common findings are lack of discussion, argumentation and challenging ideas (Guzdial 1997, Hewitt & Teplovs 1999, Lipponen et al., 2003) here referred to by Arnseth and Ludvigsen (2006).

Arnseth and Ludvigsen (2006) argue that research within the systemic approach:

> [..] does not provide detailed information about how changes in teaching and learning practices actually come about and are negotiated in dialogue among participants responding to various normative features of the setting (pp.180)

The authors claim that the general problem with the systemic approach and its analytic practice is that the nature of teaching and learning is predefined at the outset, but how the participants actively establish contexts for learning is disregarded as analytically uninteresting. Within this approach researchers may be in danger of only seeing what they are looking for, with a focus on idealized models. Doing so may result in missing crucial aspects of the data material, and the students' learning processes (Furberg, 2010). However, a systemic approach can give useful information about correlations between variables and make it possible to do systemic comparisons across datasets, as shown in the review above. Thus, both approaches are needed in order to gain understanding an insight of the CSCL field (Arnseth & Ludvigsen, 2006; Ludvigsen & Mørch, 2009).

In order to obtain a rich understanding of the complexity of CSCL environments, and the students' meaning making processes, it is crucial to take a holistic view. The interaction, the artefacts and the institutional setting is important to take into account, because this is where the meanings and effects of CSCL tools become available for study (Arnseth & Ludvigsen, 2006). When taking the unfolding of the students' interaction, the interplay with the technology and institutional setting into account in the analysis, it might give important information about how CSCL tools should be designed and redesigned un order to achieve the desired result. As the focus of my empirical study is students working collaboratively with a computer-based inquiry environment, my claim is that the dialogical approach is the most suitable approach as it makes the interaction, artefacts and institutional practices available for study.

4 Empirical setting and methods

In this chapter, I will present the empirical setting and the methods used in the thesis. Firstly, I will give a description of the empirical setting and the computer-based inquiry environment SCY-Lab, in addition to a description of the data material. Secondly, I will present the analytical procedures and the selection of data material. Thirdly, I will discuss the quality of the research conducted, with regards to validity, reliability, generalization, ethics, strengths and weaknesses.

4.1 The empirical setting

The data material which this thesis is based on is part of the SCY project, and the data collection took place in March 2010 at an upper secondary school located just outside Oslo. The students at this school are mostly high achievers, as the school has high requirements for admission. The SCY project is EU-founded and involves 12 participating partners from different countries, who represent diverse disciplines and work with design and development. The project has two main aims, which is to develop an innovative computer-based inquiry environment called SCY-Lab, and to gain further understanding of students' learning with computer-based inquiry environments. The Oslo trial was the first iteration of trials in Norway, and other trials have been conducted in the participating countries. The data collection is within the qualitative field of research, and was informed by design experiments, as it both entailed an "engineering" of the educational environment, and studying the forms of learning that happens within this context (Brown, 1992; Cobb, Confrey, diSessa, Lehrer, Schauble 2003, pp. 9). One of the objectives with design experiments is to study learning and interactions in a naturalistic setting and at the same time examine the impact of particular learning designs (Furberg, 2010). As the chosen approach in this thesis is anchored within the sociocultural perspective, there are some differences in the research conducted in this thesis, from the "traditional" design based research (Krange & Ludvigsen, 2009). These differences are mainly related to the analytical approach, which I will come back to later in this chapter.

The planning of the Oslo trial was done by the researchers involved in the SCY project at InterMedia in Oslo. I was present at some of the planning meetings, in order to gain insight of the process and meet the involved teachers from the school were the trial was held. Also, I took part in the data collection, and my role will be described in further detail later in this

chapter. The Oslo trial was conducted in four consecutive Wednesdays, 5 hours each day. From three classes, 91 students were available for the trial, but because of technical limitations, the maximum number of students was set to 20. One of the researchers visited the school and informed the students about the upcoming trial, and they were asked to volunteer. Out of the available 91 students, 45 volunteered to join the trial, and 20 students were randomly selected. In the selection, the researchers tried to keep a balance of girls and boys, as the volunteers were mostly girls. 8 boys and 12 girls participated in the trial, forming 5 groups of 4 students in each group.

4.1.1 SCY-Lab and Google SketchUp

SCY-Lab is a computer-based inquiry environment, where the intention is that students will engage in collaborative scientific inquiry processes, where they pose questions, search for information, follow lines of investigation and gather data while discussing and collaborating with each other. The process of scientific often includes phases of orientation, stating hypotheses experimentation, creating models and theories, and evaluation, and is seen as an ideal way of learning science, with focus on methods and processes used by scientists (van Joolingen et al. 2007). van Joolingen et al. describe the main claim of inquiry learning this way:

> [..] engaging learners in scientific processes helps them build a personal knowledge base that is scientific, in the sense that they can use this knowledge to predict and explain what they observe in the natural world (2007, pp. 111)

The students are intended to end up with more or less concrete products, called Emerging Learning Objects (ELOs), in form of notes, reports and drawings. Also, they are supposed to share their ELOs with each other, and to be inspired and to elaborate on each other's work.

In the Oslo trial, the students were given the mission of designing a CO2 friendly house. The mission will be described in further detail later in this chapter. The provided mission should be solved through different learning activities, with the use of SCY-Lab and the embedded tools. These resources consist of among others a drawing tool, a planning tool and a simulator where the students can insert values and measures, and make calculations. Both the drawing and the planning tool were merely not used during the trial, due to limitations in the technology and because the students found alternative tools for drawing, like Google

SketchUp. Google SketchUp and the simulator in SCY-Lab will be described in detail below, as these two tools were used the most by the students.

Google SketchUp

As mentioned above, the drawing tool in SCY-Lab was not used to a large extent during the project. Instead, some of the students used Google SketchUp, which is a 3D drawing tool as shown in Figure 1. Google SketchUp was used in order to draw the house, and to estimate the area of the different parts of their house, such as walls, floor, roof, windows and so on.

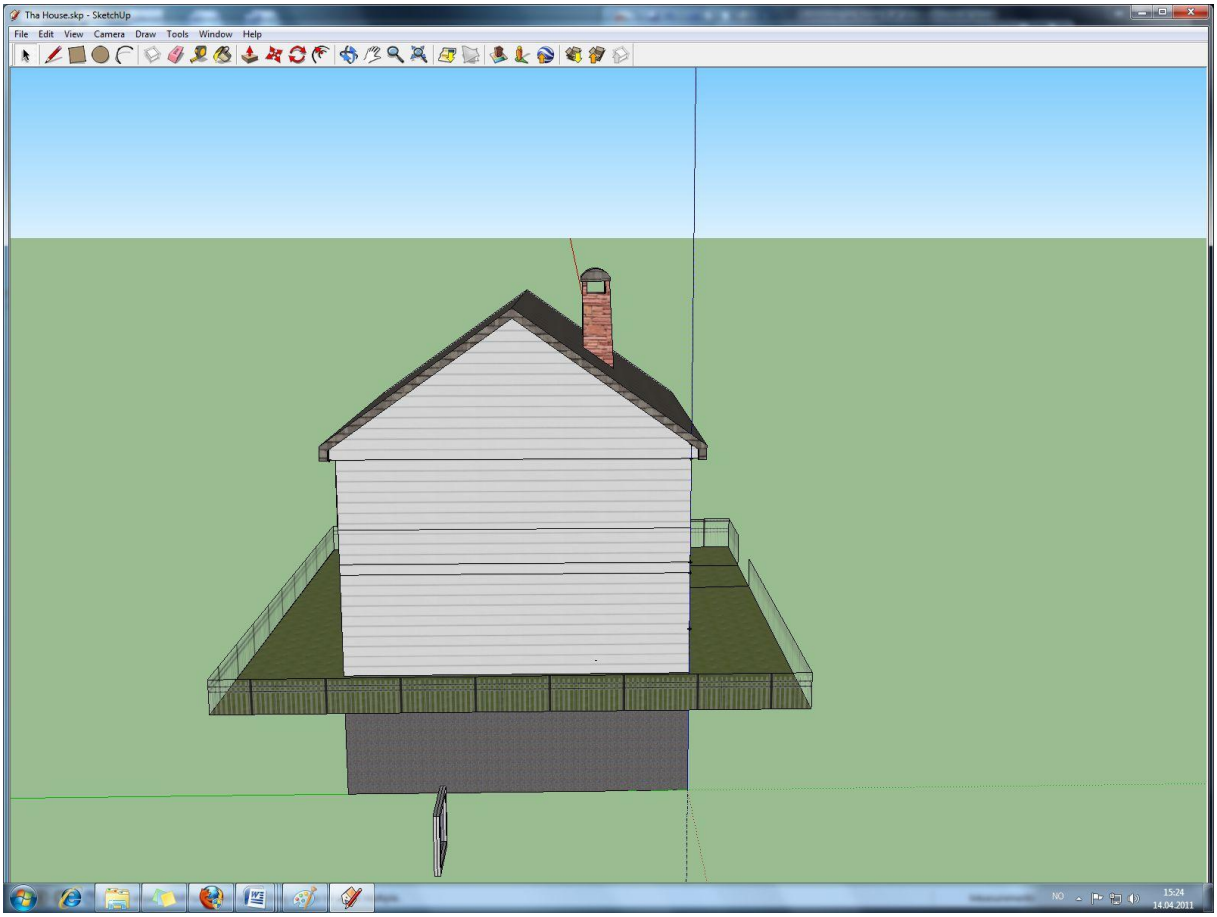

Figure 1: Screenshot of students' drawing in Google SketchUp

The SCY-Lab simulator

The mission the students in the trial were given was to design a CO2 friendly house, and the main activity consisted of using the simulator in order to get a satisfying "heat loss coefficient" and U-factor, namely little heat loss and solid insulation. In the simulator as shown in Figure 2, the students could manipulate a number of parameters, such as house size,

materials for structure and insulation, measures and values. More precisely, the students could work their way through the different tabs in the simulator, and make choices for each part of the house. This way, the students could calculate the CO2 values of their house, and see how their choices would affect the U-factor and heat loss coefficient of their house. Also, the students had to choose an outside temperature and duration of the calculation.

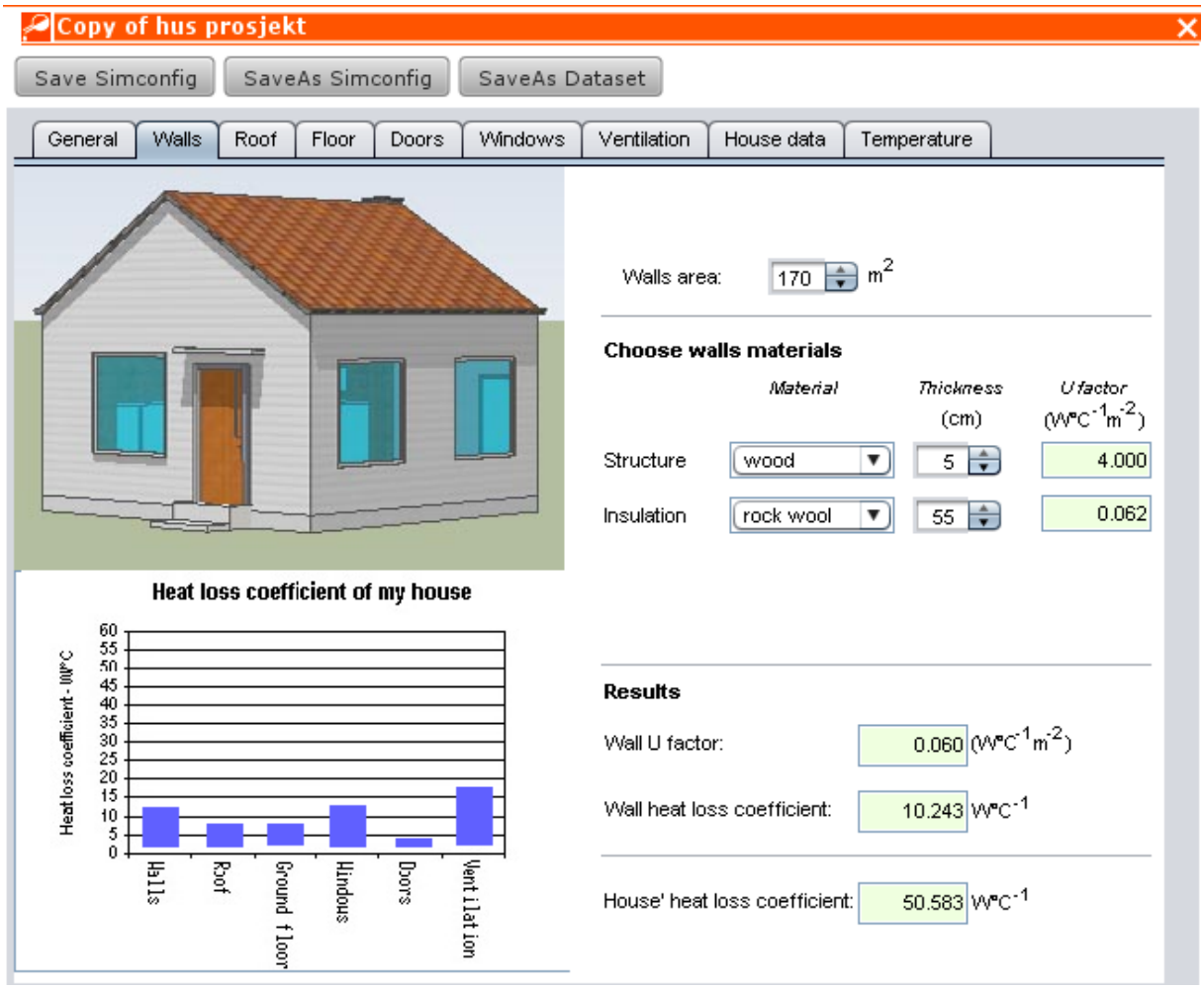

Figure 2: Screenshot from the students' calculations in the simulator

The CO2 mission

In the trial, the students were given the mission to design a CO2 friendly house for their own county, using SCY-Lab. The mission consisted of several tasks, and most of these tasks included SCY-Lab. The first day of the trial, the technology was not stable enough to be used. Therefore, the students were introduced to the mission and were given a word document with information taken from SCY-Lab.

As mentioned earlier, 20 students participated in the trial, and formed 5 groups with 4 students in each group. I will in the following present the timeline and progress of the project which took place over 4 consecutive Wednesdays, for 5 hours each day.

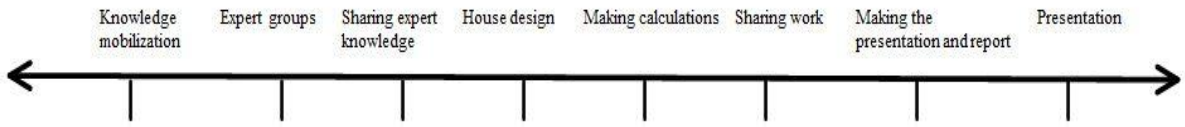

Figure 3: Project timeline, the CO2 mission

In the setting of *knowledge mobilization*, the students had received the CO2 mission and sat together in their groups brainstorming, searching online for information, making mind maps and planning their project work. At this point, the students had not yet been introduced to the technology, as it was unstable. After the students had finished the mind map activity, they were organized into so-called expert groups. In the setting of *expert groups*, the students in each initial group were given a topic for them to become experts in. The students with the same given topic were put together in temporarily groups, called expert groups. In these groups, the students were supposed to discuss and explore the topic in order to gain deeper knowledge to bring back to their original groups. When the students were finished in their expert groups, they moved on to the sharing their expert knowledge. In the setting of *sharing expert knowledge*, the students were back in their initial groups and shared their topics of expertise from the expert groups. The students were taking turns presenting their topics to their peers. After the sharing activity was done, the students started on their house design. In the setting of *house design*, the students were planning and drawing their house. Also, they were to put measures on their drawings, which would become useful further out in the project. The students had different approaches drawing their house, and most of them started out with trying the drawing tool in SCY-Lab. After a short while, the students moved over to use alternative tools such as pen and paper and Google SketchUp. One of the groups used the game Sims in order to make their final version of their house drawing. After the drawing and planning of the house was done, the students began making calculations. In the setting of *making calculations*, the students were calculating the CO2 values of their house. This meant that they had to use the simulator in SCY-Lab in order to get a satisfying U-factor and heat loss coefficient. They manipulated a number of parameters, and chose between different

materials, values and measures in order to make a CO2 friendly house. When they finished this activity, the students moved on to write up their end products. In the setting of *making the presentation and report*, the students were finishing the project and making their end products. These end products were a presentation to be held for the rest of the class, together with a written report to be handed in at the end of the project. In the setting of *presentation*, each group presented their work for the rest of the class.

4.1.2 Description of data material

The main data material reported in this thesis is consists of video recordings which is capturing the student group activities during their work with the project. Interviews, students' products and field notes serve as contextualizing data material.

Type of data	**Descriptions**	**Status of data**
Video recordings	20 hours in total, capturing student group activity during the project	Core data
Documents	Handouts to students: The mission	Contextualizing data
	Researchers field notes	Contextualizing data
	Students' products	Contextualizing data
Video-taped interviews	Semi-structured group interviews with 4 groups of students	Contextualizing data

Table 1: Lists of data and their status

The video recordings consist of material of three collaborating groups of students, with four students in each group. The groups were videotaped as they were sitting together in groups with their laptops in front of them in the classroom. The students were both sitting with a laptop each, and sometimes they split up in collaborating dyads sharing one laptop. At one occasion, one of the groups sat all four in front of one laptop. This is described in more detail in the chapter with presented findings. As the students moved and changes places in their collaborating groups, the camera was moved in order to catch the activities. In order to capture the sound, there was one microphone attached to the camera, and one was placed on the table in front of the students.

I was a part of the research team in the Oslo trial and data collection. A fellow master student and I were in charge of the camera and video recordings of one of the groups. This involved moving the camera in order to catch the student activities, watching practical concerns like video cassettes and microphones, taking field notes and assisting the other researchers if needed. We were present at the school all through the trial and data collection. Being part of a research group and a large project like SCY gives a lot of insight into an interesting research process, but it also means that most decisions concerning the data collecting was not in my hands as a master student.

4.2 Analytical procedures

I will in the following focus on the analytical procedures of interaction analysis which is conducted in this thesis. Also, I will present the process of selecting the data material.

4.2.1 Interaction analysis and interaction trajectories

The analytic procedures conducted in this thesis can be described as interaction analysis, based on the definition by Jordan & Henderson (1995):

> [A]n interdisciplinary method for the empirical investigation of the interaction of human beings with each other and with objects in their environment. It investigates human activities such as talk, nonverbal interaction, and the use of artifacts and technologies, identifying routine practices and problems and the resources for their solution (pp. 39).

A basic underlying assumption within the field of interaction analysis is that action and knowledge are social in origin, and situated in practices and contexts. Knowledge and practice is therefore not located in the minds of the individual, but in the interaction between individuals in a given context (Jordan & Henderson, 1995). Questions of interest within interaction analysis often concern how individuals make sense of each other's actions. Thus, the job of the analyst is to look for and specify where the individuals do the sense making and makes it visible for each other (Jordan & Henderson, 1995). In other words, the joint activity of meaning and sense making becomes visible for the analyst through interaction analysis, as the analyst is sensible to how this meaning and sense making is expressed by the individuals. Furberg (2010) argues that using interaction analysis allows a focus on both the micro-level analysis, such as individuals' interaction and engagement with artefacts, together with

ethnographic data. This gives a fuller understanding of the social interaction, and how micro-level activities are part of institutional practices.

As I argued in the review chapter, I have found the dialogical approach most fruitful, as it takes the institutional factors into account together with mediating artefacts and interaction and makes it available for study. This is in line with the claims by Krange and Ludvigsen (2009), as they argue that adopting a sociocultural and dialogical approach differs somewhat from the "traditional" design based research where the individual knowledge construction is the unit of analysis. Krange and Ludvigsen (2009) argue for a focus on the contextual aspects and meditational means as they become relevant in the students' interactions.

In order to understand the individual, it is necessary to understand the social relations in which the individual exists (Wertsch, 1991). The social part of language and dialog is therefore essential in understanding how people learn and create meaning together. The speakers utterances, turns and actions are depended on the actions of the interlocutor(s) engaged in the same interaction, as they are parts of a social practice. Linell (1998, pp. 71) refers to Heritage (1984a, pp. 242) when he argues that utterances are responsive both to prior contexts and contribute to renewing context. This way, utterances are both related to what has being said, at the same time as they relate what to be said next. One can therefore say that utterances cannot be seen as individual actions and that a relevant interpretation of what is being said cannot be made in isolation from other utterances. The analysis in this thesis is conducted with the interaction between the students as a starting point, with focus on their actions and orientations towards what they comprehend as relevant in the given setting (Furberg, 2010). This implies, in line with the sociocultural perspective, a focus on the students' interaction with each other, their interaction with the technology as mediating artefacts within the institutional setting of school.

The conducted analysis in this thesis follows the process of the two student groups Power Puff and Thumbs Up, with focus on their collaboration, interaction and meaning making process. The third group was not chosen for analysis due to the nature of the group. Compared to the other two groups, there was a lesser extent of interaction, and the group mostly worked individually. Compared to the two groups I have chosen, the third group was most alike Thumbs Up, but without the same data quality. As my main focus in collaboration, I chose the two groups were the interaction was most visible, and because the two groups represented differences in how they worked together. Analytically, I will use the concept of "interaction

trajectory", which refers to actions that happen over a period of time. This is based on the work by Dreier (1999), Lave (1997) Mercer (2000), (as cited in Furberg & Ludvigsen, 2008). Within the sociocultural perspective, the construction of knowledge and meaning making is considered as something that happens over time. Thus, by focusing on interaction trajectories, the meaning making process and collaboration over time becomes available for study.

In the analysis, I have chosen excerpts from four settings in the project timeline, which is presented chronologically. This makes it possible to see how the students' orientations changes of time, and how topics for discussion are negotiated, decisions are made, or revisited at a later point in the project work. Derry et al. (2010) make a distinction between an inductive approach and a deductive approach when selecting data material for analysis. According to this distinction, the excerpts in this thesis is selected with an more or less inductive approach, as the video corpus has first been investigated in its entirety and then in greater depth. When I started to familiarize myself with the data material, I had broad research questions in mind. I have viewed the video corpus several times, and discussed it with the SCY research group. The chosen excerpts were selected as they show the students' meaning making explicitly, and they cover main themes both with regards to the different parts of the project and to the students' collaboration. Altogether, the chosen excerpts constitute what can be seen as a representative sample from the students' work with the project (Derry et al., 2010).

Below in Figure 4, the project timeline is presented with the four settings where the chosen excerpts are taken from: *Sharing expert knowledge, House design, Making calculations and Making the presentation and report.*

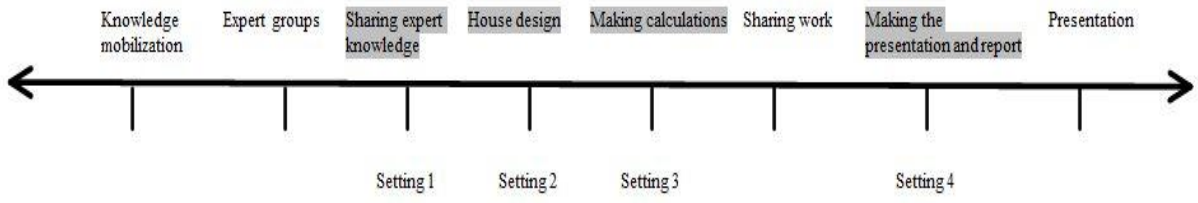

Figure 4: Project timeline, the CO2 mission, with the chosen settings

Linell (1998) uses the term "episodes" when describing sequences of interaction which is relatively bounded:

> An episode is basically a train of discursive events, or a sequence of collective actions. Most, but not all, episodes are "about" something specific in the world; they are focused on attend to and move within some kind of "topic" [...] (pp.187)

Related to this, it is possible to argue that the excerpts I have chosen in my analysis represent episodes from the four project settings mentioned above. As my focus in this thesis is on the students' collaboration, I wish to show how the students' actions unfold in the different parts of the project with diverse topics of concern. I have chosen excerpts from the above settings because they represent and provide insight into large parts of the students' work with the project, and different aspects of their collaboration.

4.3 Reflection on research quality

In the following, I will discuss the quality of the research conducted, with regards to validity, reliability, generalization and ethics. I will focus on both strengths and weaknesses concerning my research.

4.3.1 Reliability

Within the field of quantitative research, reliability concerns whether a repeated measurement produces the same results, using the same test and under the same conditions (Silverman, 2001). According to Kvale and Brinkmann (2009), reliability in qualitative research relates to the consistency and trustworthiness of the research findings. In order to strengthen the reliability of a study, the researcher can provide a thorough documentation of the research procedures, according to Kirk and Miller (1986). As one of the most important reliability aspects of interaction analysis is how the data material is presented and made available for analysis (Furberg, 2010), this is where I will have my main focus in relation to my empirical study.

Firstly, the transcriptions of the video recorded material were done in accordance to standardized transcripts conventions. By doing so, the transcribed data material gained a stronger position regarding reliability, compared to field notes. This is because use of a standardized transcript notation gives the readers a fuller description of the data material and the activity that is happening. In addition it is possible for the reader to consider the

trustworthiness of the analyzed data. The applied transcripts conventions is based on Jefferson's transcription conventions (Jefferson, 2004), and is shown in Table 2.

[ ]	Text in square brackets represents clarifying information
=	Indicates the break and subsequent continuation of a single utterance
?	Rising intonation
:	Indicates prolongation of a sound
Underlined	Emphasis in talk
(.)	Short pause in speech
-	Single dash in the middle of a word denotes that the speaker interrupts herself
--	Double dash at the end of an utterance indicates that the speaker's utterance is incomplete
CAPITALS	Loud speak
<text>	Indicates that the enclosed speech was delivered more slowly than usual for the speaker
`Courier New`	Student's reading from the screen is typed in `Courier New`

Table 2: Transcript notations used in the analysis of interaction excerpts

Secondly, the reliability in this study was strengthened by the display of the data material which is analyzed, together with the actual analysis. This way, the readers can follow the interaction as well as the step-by-step analysis, and are free to make their own interpretations of the ongoing action, the provided analysis and whether it is trustworthy. Thirdly, I have as a master student been a part of SCY project group at InterMedia in Oslo. During this time, I have participated in several meetings where the whole corpus of data material from the Oslo trial has been discussed as a joint activity. Furthermore, my main- and co-supervisor, as well as my fellow students have given me feedback and provided analytic insight on both the transcriptions and the analysis in this thesis. Also, because they know the whole corpus of data material well, they have been able to give my feedback concerning whether I have selected the right excerpts.

Altogether, I believe that these efforts have strengthened the reliability of my empirical study. This being said, I am aware of the fact that further efforts could have been made in order to strengthen the reliability even more. For instance, the intersubjective reliability could have been strengthen by having other researchers systematically transcribe and analyze the same excerpts as I have, and compare their notations and analysis against mine (Kvale & Brinkmann, 2009). Due to time limitations this has not been done.

4.3.2 Validity

The term "validity" is another word for truth in everyday language, and refers to the correctness and strength of an argument (Silverman, 2005; Kvale & Brinkmann, 2009). According to Kvale and Brinkmann (2009), validity relates to the degree a method investigates what it is intended to investigate. In qualitative research, validity can be seen in relation to whether the analytic claims about the data material is seen as convincing, together with the strategies used (Kvale & Brinkmann, 2009).

Some of the points I have drawn attention to regarding the reliability of this thesis, also concerns the validity. As I mentioned before, the use of interaction analysis in this thesis provides the readers with a transparency, as the readers are able to follow the researcher's analytical considerations. Also, being part of a research group with joint analytical efforts and feedback contribute to strengthen the validity of this thesis.

Furthermore, the use of ethnographic data material like in this thesis provides the readers with a somewhat rich description of the social setting. By providing rich descriptions, the reader is invited into the research setting and has the opportunity to make decisions whether the study is credible or not (Kvale & Brinkmann, 2009; Silverman, 2001). Nonetheless, these rich descriptions may also be a potential weakness, as argued by Mehan (1978), (cited in Silverman, 2005). The term "anecdotalism" refers to how researchers with in-depth access to their data material may have problems convincing themselves and others that their findings are based on a genuine and critical investigation of the whole material, and not just well-chosen examples that fit to their assumptions.

All through the work with this thesis, I have been concerned with obtaining a solid overview of the data material, in order to be as sure as possible that my findings are based on a genuine and critical investigation of the whole material. Also, the fact that I have been part of a research group who has good insight into the whole corpus of data material has been very helpful in order for to me to feel relatively confident about my choice of excerpts from the data material, and that they are not just well-chosen examples that fit my assumptions. During the data collection, and throughout the work with this thesis, I have had researchers, PhD candidates and fellow master students who I could discuss and test my comprehension of the data material with. Also, through meetings and talks with my main- and co-supervisor, I have

had my findings tested and challenged. This being said, the choice of excerpts and the analyses conducted are mine, and therefore also my responsibility.

4.3.3 Generalization

In quantitative research, generalization is related to whether the findings are of local interest or whether they are transferable to other subjects and situations (Kvale & Brinkmann, 2009). As the study in this thesis is of qualitative nature, it is difficult to discuss the generalizability of the premises mentioned. However, in studies conducted using interaction analysis, it is according to Ercikan and Roth (2006) possible to focus on to what extent the findings within one educational setting is applicable to other educational settings. In relation to this claim, it is relevant to bring in the term *analytical generalization* (Kvale & Brinkmann, 2009):

> *Analytical generalization* involves a reasoned judgement about the extent to which the findings of one study can be used as a guide to what might occur in another situation (pp. 263)

The claims presented in my empirical study are broad and can be seen in relation to the term analytical generalization. This is because the concluding claims in this thesis are based on theoretical perspectives, the findings from the empirical analysis and the findings of similar or related studies.

According to Furberg (2010, pp. 67), the analytical generalizability of a single study is strengthened by the findings from similar educational settings. Based on this understanding of generalizability, it is possible to argue that the claims in this thesis are contributing to strengthen the research field.

4.3.4 Ethics

As I have mentioned, the planning of the Oslo trial was done be the researchers involved in the SCY project at InterMedia in Oslo, and did not take part in this planning. However, I will focus on the efforts that have been done both by the research group and myself.

The researchers have sent a notification request to the Norwegian Social Science Data Services (NSD), which has been approved. Before the data collection could start, all the participating students had to give their written approval, in order to be videotaped. In order to

make the participating students and teachers anonymous, I have not mentioned the name and exact location of the school in this thesis. In addition, during the transcriptions of the data material, all the student names have been replaced with pseudonyms. The collected data material will be stored securely at InterMedia at the University of Oslo.

During the Oslo trial and data collection, I was open towards the students about my role as a master student, and the fact that the video tapes would be my data material for this thesis.

5 Analysis

In the following section, I will analyse the process of the two student groups Power Puff and Thumbs Up, with focus on their collaboration, interaction and meaning making process. As described before, I will in my analysis use the concept of interaction trajectories, which refers to actions that happens over time. This is based on the work by Dreier (1999), Lave (1997) Mercer (2000), (as cited in Furberg & Ludvigsen, 2008). By focusing on interaction trajectories, the students' meaning making process and collaboration over time becomes available for study.

In Figure 5 is the timeline for the project, which also shows where in the process my excerpts are taken from: *Sharing expert knowledge*, *House design, Making calculations and Making the presentation and report.*

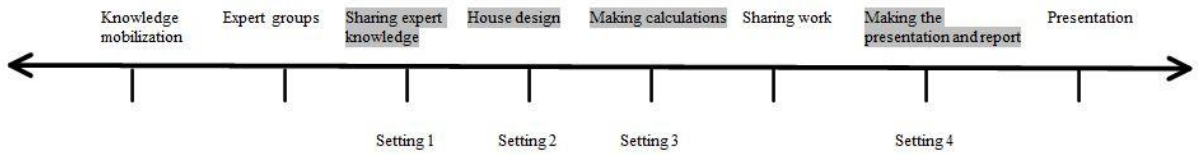

Figure 5: Project timeline, the CO2 mission with the chosen settings

I will present excerpts of the interaction trajectory of Power Puff first, and then do the same with Thumbs Up. In the analyses of both groups, I will present the settings the excerpts are taken from, and identify key points which I will return to in the discussion. I will also provide a summary of both groups.

5.1 Power Puff

In the following, excerpts from the interaction trajectory of the group Power Puff will be presented. The group consisted of four girls: Claire, Kate, Linda and Rachel. During the project, they were sitting together with their laptops. The students shifted between working in dyads and working together all four of them. Through the project, they were attuned to each other and were making jointly decisions.

5.1.1 Setting 1: "Sharing expert knowledge"

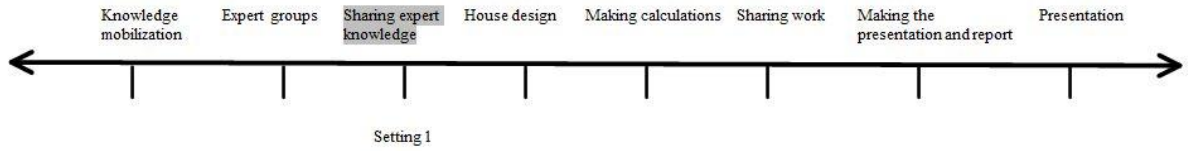

Figure 6: Project timeline, setting 1

In the following two excerpts, two of the students in the Power Puff group are presenting their topics from their expert groups (Figure 6). I have chosen these excerpts because they give an insight into how the students in this group typically talk about scientific concepts.

The students are sitting together, with their laptops in front of them, two on each side of the table. They are back from their expert groups, and Linda has started to present her field of expertise, which is solar cells. She is in the process of explaining the photoelectric effect in solar panels, which converts sunlight into electricity. She has her laptop in front of her, with a document she produced in her expert group. As she is speaking, she is watching the screen with the document occasionally. Then Linda stops her explanation in order to ask to others if they understand.

Excerpt PP1a

1.	Linda:	Yes, u:.m, and then it is negatively charged. And both these plates are added a different substance, at that is what is called in a way that the plates are doped. Because it lacks or has too many electrons
2.	Linda:	Did you get the first part?
3.	Claire:	I didn't quite understand, sorry
4.	Linda:	Okay, m::: Yes, [laughs] U:m, you can get this afterwards [Points at OneNote notes] It is easier= I'm not that good at explaining but=
5.	Claire:	Yes, you are
6.	Linda:	No. U::m, so, how solar cells work is then kind of, I did not quite understand it, but I can try, [laughs] okay. U::m, if you say that it is in a way, [showing with her hands] n-type, or a n-type silicon plate is here, and the p-type silicon plate is

		here, in a way, then you have this kind of battery, or in a way, a slide, as the teacher called it, between= It is very difficult to get if you don't understand it, but= Solar cells hit the solar cell, and kicks electrons over from the n-plate, to the p-plate, if you understand what I mean
7.	Rachel:	Yes
8.	Linda:	Because it goes downhill in a way= The slide, a slide you know, and the electrons want to go back, u::m, back to the p-plate, and because of that barrier, because it was a slide, right, so it cannot go upwards
9.	Rachel:	No
10.	Linda:	U::m, and then the electrons go through an external circuit, in a way, and that's when the electric circuit makes light, and it becomes light, or = electricity. U:m, if you understood some of that
11.	Rachel:	Yes, I think I understand
12.	Claire:	[Looks at Linda's screen] Oh yes, it is like the= Like the electric car, you know
13.	Linda:	Mm
14.	Claire:	Yes, okay, then I got it
15.	Linda:	[Turns her laptop towards the rest of the group] Here is a drawing. The solar cells are going through, or they are kicked down there, men they want to go back again, in a way, or wait= It's opposite. It is= They slide down here= Or wait=
16.	Claire:	[Points at Linda's screen] They move into the blue
17.	Linda:	Yes, so they= They move into the blue, and they really want to go there, but they have to go through here, in a way
18.	Claire:	But it is only the electrons that go through there, and in a way the rest--
19.	Linda:	No, the rest stays here, in a way
20.	Claire:	Oh YE::S
21.	Linda:	Because it is only solar energy that goes in here, in a way
22.	Claire:	Mm::: [confirmative]

In the opening of the excerpt, we see that Linda stops her presentation of solar cells in order to ask her three group members if they follow her explanation. She asks if they understood the first part (line 2), and Claire says that she did not understand, adding that she is sorry (line 3). Linda hesitates and replies that Claire can have her OneNote document afterwards, adding that it would be easier and that she is not very good at explaining (4). Claire assures her that she is (line 5), and Linda continues with her explanation. Linda stops again, saying that it is not easy to get if one does not understand (6). She explains how electrons are being kicked from the n-plate to the p-plate, referring to the explanation given by the teacher and the use of an everyday concept like "slide", and she asks the girls if they understand (line 6). Rachel confirms, and Linda keeps going. Linda asks Rachel (line 10) if she understands, and Rachel replies thinks she does (line 11). At a point, Claire looks at Linda's screen, and recognizes what she sees (12), relating it to an electric car. Linda confirms (line 13), and Claire says that then she understands (line 14). Linda turns her laptop around to show the others a model of a solar panel, and continues her explanation, this time by relating it to the model on the screen (line 15). Claire points at the screen and comments on what she sees, and that the electrons move towards the blue (line 16). Linda confirms and carries on, Claire comments and Linda corrects her (line 17, 18, 19). The excerpt is concluded with Claire exclaiming "oh yes" when

hearing Linda's reply, signalizing that she understands what Linda tries to explain to her. Linda answers with an elaboration of her explanation (21), and Claire replies with a confirmative "Mm" (line 22).

There are some main points I wish to highlight from this excerpt. The first point concerns how Linda tries to invite the others students into her explanation, by repeatedly asking if they understand and follow her explanation. Linda tries different strategies to make her explanation of solar cells and the photoelectric effect understandable, such as referring to an everyday concept introduced by the teacher, as well as using the model on her laptop. The second point concerns how the other students are inviting themselves into the conversation by letting Linda know when they do not follow her, and by asking questions. The third point concerns the role of the model of the solar panel. As we can see in the excerpt, it is when Claire discovers the model that she indicates that she understands. The introduction and discovery of the model takes the interaction another direction, where the students use the model in order to make sense of the topic, and relate it to things they are familiar with; such as an electric car. This shows how the solar panel model becomes a resource in the students' sense making of how solar panels work.

In the following excerpt, it is Rachel's turn to present her topic from the expert group she participated in. She is explaining to the other students about the functionality of heat pumps, looking regularly at a document on her laptop which she made in the expert group. All four students are sitting around a table, each one with their laptop in front of them.

Excerpt PP1b

1.	Rachel:	If the condenser is inside a private home, the temperature will be from 15 to 22 degrees, u::m yes, that is actually lower than the hot steam, so, when heat goes from the place with the highest temperature, to the place with the lowest, out of the tube, and it warms up the house. At the same time, the steam is converted into liquid again, which condenses. Also, the energy is then released as condense heat, then. Also, in order to return to square one= the liquid is squeezed through a pressure reducing valve. It will then get more speed and less pressure, so the temperature drops, and then= e:m, and the valve is set so that it falls back to the starting point, and it can go back to start and re-heat, and then repeat the process
2.	Kate:	Okay
3.	Rachel:	Yes, if you understood that?
4.	Linda:	M: I think so. But they way it goes into the house= when the heat goes into the house
5.	Rachel:	Yes
6.	Linda:	I didn't quite understand why= Or how it happened
7.	Rachel:	Because it kind of [showing with her arms]
8.	Linda:	It is in a way, from the highest to the warmest, no, the other way around
9.	Rachel:	Okay, for instance from, or, kind of from

10.	Claire:	But do you have a picture or something like that, because then it would be easier to see
11.	Rachel:	Let's see, I can find something because I have lots of links on It's learning (.) There is a lot like animation and stuff that is out there so = we can try to look at those in the [looking at It's learning] (.) It's like that movie maybe. Let's see= Looks like this test [Angles the screen so everyone can see] [The students finish the sharing of expert knowledge and continues to work on their mind map]

The excerpts starts with Rachel explaining the functionality of heat pumps to the other students, and asks them if they understand (line 1, 3). Linda answers that she thinks so, and adds that it was some parts that she did not understand (line 4, 6). Rachel tries to elaborate (line 7, 10), and Linda joins in (8). Then Claire asks if Rachel has a model "or something", as she thinks that would make it easier to see (line 10). Rachel looks up some information on her laptop, in order to show the others (line 11).

In this excerpt, we see some of the same dynamics as in the first excerpt, and I wish to highlight some main points. The first point is about how Rachel is inviting the others students into the conversation, by using the same approach as Linda, and asking them whether they understand. The second point concerns how the other students are inviting themselves into the conversation by asking her questions, like we saw in the first excerpt. The third point I wish to highlight is how the students wish to introduce a model they can look at, in order to make it more understandable, like we saw in the earlier excerpt.

We have now seen two excerpts where the students in Power Puff presented their topics of expert knowledge. In the excerpts that follow, they have moved on to another part of the project.

5.1.2 Setting 2: "House design"

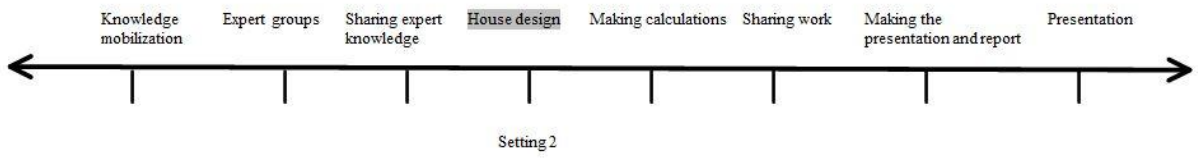

Figure 7: Project timeline, setting 2

In the following two excerpts, we meet the students as they have started to plan and draw their house (Figure 7). The drawings are shown in Figure 8 and Figure 9. Also, they have started to

apply measures on the drawing, which they would need later in the project. The two excerpts are chosen because they are typical examples of how the students in the Power Puff group were attuned to each other and made decisions together.

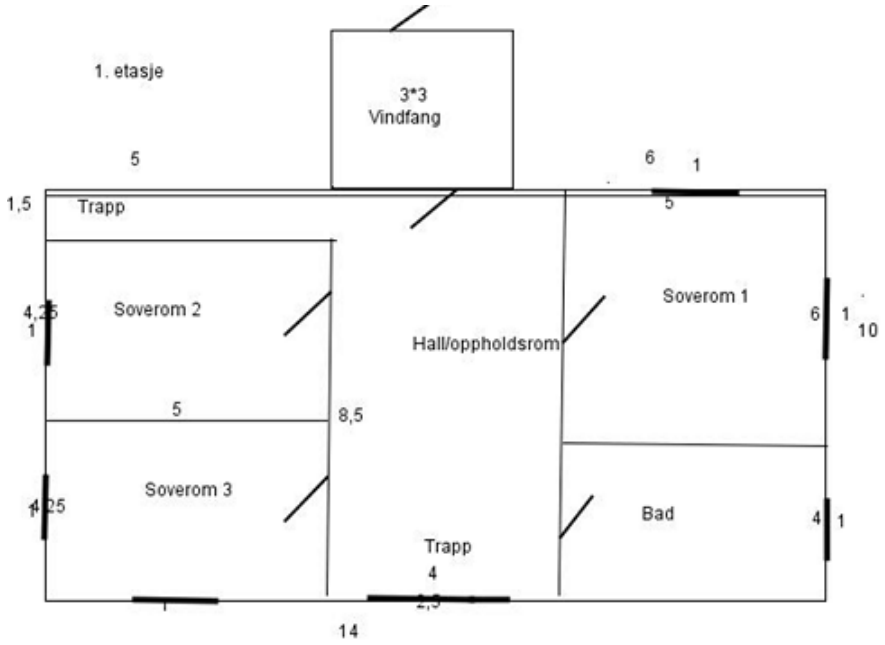

Figure 8: Students' house drawing, made in SCY-Lab

Figure 9: Students' final house drawing, made in Sims

All four of them are sitting around a table, working in dyads using their laptops. In this excerpt, we meet Claire and Rachel as they are using the drawing tool in SCY-Lab to draw their house with partitioning.

Excerpt PP2a

1.	Claire:	Do you want to draw? You were much better at it than me
2.	Rachel:	Let's see:
3.	Claire:	[Laughs a little] I just failed all the time
4.	Rachel:	No.
5.	Rachel:	Okay, so- How far have we come? We will have-- At least the main bedroom there [points at the screen]
6.	Claire:	Yes, and we were going to place the bathroom there [points] So, it is three floors
7.	Rachel:	Yes, but were we supposed to have the shed [inaudible] laundry room first and then the bathroom, or should we have--
8.	Claire:	[Interrupts Rachel] No, we were supposed to have the laundry room in the basement
9.	Rachel:	That was the way it was [Rachel wipes the screen, and they both giggle]
10.	Rachel:	So= Here= Here maybe [starting to draw the room]
11.	Claire:	Yes
12.	Claire:	Place it a little further away, then. Because we were thinking to place to parental bedroom there [points at the screen]
13.	Rachel:	Yes
14.	Claire:	There

In the opening of the excerpt Claire and Rachel are deciding that Rachel will do the drawing (line 1, 2, 3), and Rachel asks Claire how far they have come (line 5). They discuss where to place the bathroom and laundry room (line 6, 7, 8, 9). Rachel tries to find where to start the drawing (line 10), Claire shows her (line 12) and Rachel begins to draw (line 13).

In this excerpt, like we have seen in the excerpts before, the students continue to invite each other into the conversation and to share their opinions, by formulating their utterances as questions. Also, the students are making jointly decisions.

The students work together in dyads for while, before they reorganize and start to work on a new task. In the following excerpt, the four students are sitting together in front of one laptop. They are working on a new topic, which is to enter the measures of the walls on the drawing made by Claire and Rachel. Claire is in charge of the laptop, and the other three students are sitting around her watching the screen.

Excerpt PP2b

1.	Claire:	Okay, let's find out how many meters they should be
2.	Rachel:	Let's do that
3.	Claire:	How big should that hallway be? Four times four? Or three times three?

4.	Rachel:	Isn't it enough with three times three?
5.	Kate:	Yes, three times three is really quite large, so [inaudible]
6.	Claire:	Three times three [enters it in the simulator] We will do so and see how it turns out
7.	Unison:	Yes
8.	Claire:	Okay, and then the wall here, how long should it be? [Points at the screen]
9.	Claire:	Then it is five meter there= And then there are si- Six there. Five, six, three. It is fourteen meters, then. The entire wall.
10.	Rachel:	Yes [Claire enters the measures into the drawing tool in SCY-lab]
11.	Claire:	Then there are five [enters measure], and so there are six there= How long is this one then [points at one of the walls]
12.	Unison:	M:::
13.	Claire:	An where= And is this one meter, here, then this is five inside here, then
14.	Rachel:	Yes
15.	Claire:	So= I just write the numbers= I guess--
16.	Unison:	Yes
17.	Claire:	And this is also five
18.	Unison:	Yes [Claire enters more measures]

Claire starts out with suggesting that they should decide on the measures of the walls on their house (line 1). She suggests some measures (line 3), Rachel and Kate share their opinions (line 4, 5), and Claire listens to them and enters the measure (line 6). Claire continues to enter measures, and formulating her utterances as questions to the others (line 8, 9, 11, 12). The other students are confirming Claire's suggestions (line 10, 12, 14, 16, 18).

This excerpt shows some of the same kind of interaction as the excerpts before. Based on the excerpts presented so far, it is now possible to see a pattern in how the students in Power Puff are talking to each other and making decisions. Decisions are made jointly; they are working together and inviting each other to join in. In this excerpt this is done by formulating their utterances as questions.

We have now seen two excerpts here the students in Power Puff worked with the design of their house. In the excerpts that follow are they going to start to work with the simulator and calculate values for their house.

5.1.3 Setting 3: "Making calculations"

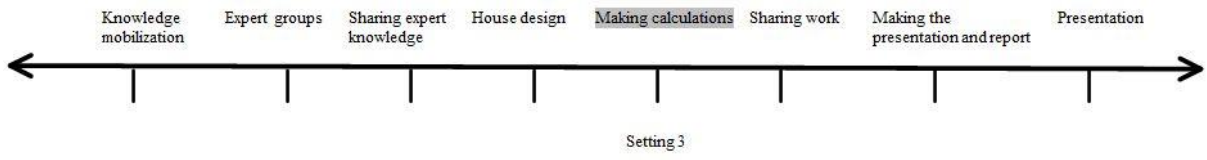

Figure 10: Project timeline, setting 3

In the following two excerpts, the students work with calculating the CO2 values of their house (Figure 10). They are using the simulator in SCY-Lab where they can choose between different materials and values. In order to design a CO2 friendly house, the students were supposed to find materials and calculate values that provided a satisfying heat loss coefficient and a low U-factor, namely little heat loss and solid insulation. I have chosen the excerpts because they give good insight into how the students in Power Puff were gathering information outside the learning environment, and how they use this information in their decision making.

One of the next activities for the students is to calculate the CO2 values of their house. As a part of this, they need to decide what type of insulation to use for the walls. In the simulator, the students can choose from a range of different materials, and as wells as the thickness of the material. When choosing material and thickness, they can see how this affects the emissions of their house. In this excerpt, we meet the Power Puff group as they have discovered the different alternatives they have concerning insulation material. Kate starts to read these out loud.

Excerpt PP3a

1.	Kate:	But what should we have? Should we use `hemp, flax, polystiyene, therma foam, mineral wool, rock wool, glass wool?`
2.	Rachel:	Whatever works best [laughs] (.)
3.	Kate:	Okay, we will search <Insulation>
4.	Linda:	Yes
5.	Kate:	Yes= `Environment house` [Kate enters a web page where it says "environment house" in the headline] (.)
6.	Linda:	Is there something about the isolation there? (.)
7.	Kate:	Glava= That there is no Glava--
8.	Kate:	Glass wadding= We won't have that then (.)
9.		[The girls are quiet for a while and read on the screen in front of them. It is a site with a lot of text.]
10.	Kate:	Rock wool [Points at the screen and looks at Linda]
11.	Linda:	Yeah= Maybe we should use that then
12.	Kate:	That? [Opens the simulator again]
13.	Linda:	Yeah
14.	Kate:	So we= We won't have glass wool, we will have have rock wool. Because glass wool is not environmental friendly [chooses a material in the simulation]
15.	Rachel:	Okay
16.	Kate:	Did we find out= That's what they use in Glava=
17.	Claire:	But we have to use Glava, then= To isolate=

18.	Kate:	But, it says= Yes, but we like to use another type= Not the Glava brand kind of= Because it says= Glava= Mhm= Had to tear down the walls of the house and replace Glava with this rock wool, because the kids get asthma and stuff
19.	Claire:	Then I'm going to get a lot of asthma
20.	Kate:	Not good= A very expensive repair
21.	Kate:	So we must use it [The students decide to use rock wool as insulation. Linda opens the simulator and the students start to talk about the thickness on the walls]

Linda and Kate are working with the simulator, looking at different types of insulation material for their house. Kate is browsing through the different materials, asking the others which one to use, and reading the different choices out loud (line 1). Rachel answers that they should use the best one (line 2). There is a moment of silence, and Kate suggests that they should search for insulation on the Internet. They find a webpage which says "environment house", and they are silent for a while as they read. Linda wonders if it says anything about insulation (line 6). They are silent, before Kate repeats some of the information she reads (line 7, 8). There is another pause, as the girls reads from the screen. It is a webpage with a lot of text. In line 9, Kate is enthusiastic and exclaims "rock wool" and points at the screen, where she found the information (line 9). Linda says that they can use rock wool and Kate goes back to the SCY-lab and simulator (line 10, 11). Kate sums up what they have found: they will not use glass wool, because it is not environmental friendly. They will use rock wool (line 13). Claire wants to use Glava for insulation (line 18), but Kate argues against, using the information she found on the webpage on how Glava can cause asthma (line 19). When hearing Kate's explanation about the relationship between asthma and Glava Claire seems to agree by saying "then I am going to get a lot of asthma", and Kate states that they have to use rock wool (line 20, 22). Linda opens up the simulator and the students start to talk about the thickness of the walls.

There are three main points I wish to highlight from this excerpt. The first point relates to what the students base their decisions on. When they are in doubt about what material to choose, they move outside the learning environment in order to obtain new information, and they use this information in order to make a decision. The second point concerns how the need for more information about insulation material is acknowledged when the students become aware of the range of choices of insulation provided by the simulator. The third point relates to how the students negotiate in order to make a decision. As we can see, Kate is

explicit about her arguments relating it to the information they found, and Claire seems to be convinced by her arguments.

The students agree about the material for insulation, and starts to discuss other topics related to the simulator. After a while they begin to talk about whether to use straw bale as structure for their house.

In the following excerpt, they are sitting together all four with their laptops. Claire and Rachel are on the one side of the table, and Kate and Linda on the other. They have been talking about using straw bale as structure for their house, as they have discovered in the simulator that this material gives a low U-factor. Now we meet the students as Kate is wondering what a house made of straw looks like.

Excerpt PP3b

1.	Kate:	But what does a house build of straw bale look like?
2.	Linda:	I don't know what it looks like even (.)
3.	Linda:	Search
4.	Kate:	Straw bale= Straw bale house [enters into the search engine]
5.	Linda:	Take pictures or something=
6.	Linda:	[Laughs] Yeah
7.	Kate:	Yes, but it was kind of cool= It was= Hm
8.	Kate:	But it didn't look like straw
9.	Linda:	Wow (.)
10.	Kate:	It was a nice, I was about to say--
11.	Kate:	I had somehow pictured it like that= Just a straw bale
12.	Linda:	Try and just= Click on it= See how it--
13.	Linda:	A little strange, but yes
14.	Kate:	Yes, cosy [The girls giggle]
15.	Linda:	Well
16.	Kate:	Yes, straw bale house
17.	Linda:	See, see, this is what a house made of straw bale looks like [Shows Claire the picture of the houses they have found]
18.	Kate:	This is what we will build
19.	Claire:	Cool
20.	Kate:	But I don't know= Is this a straw bale house also= It's like= This one, because it says straw bale house below= It's--
21.	Linda:	Click on it, then
22.	Claire:	Wow
23.	Kate:	I will try here = It was really cool
24.	Linda:	It may be that they have painted it, then
25.	Claire:	Yes, they may have done that
26.	Kate:	Yes, straw bale cottage
27.	Claire	It was really cool
28.	Kate:	It was really coo- Yes, it's similar to brick, kind of= Or like concrete=
29.	Rachel:	Concrete
30.	Kate:	It looks a bit trendy= Then we will get really trendy house, built of (.) Straw bale [The students end up using straw bale as structure for their house.]

In this excerpt, the students are discussing the possibility to design a house made of straw bale. Kate wonders what such a house looks like, and Linda answers that she does not know (line 1, 2). They are quiet for a short while, before Linda suggests that Kate should do a search on the Internet (3). Kate types in "straw bale house (line 4) and the girls look at the pictures that are showing (6, 7, 8, and 9). Kate thinks it looks cool, but that it does not look like straw bale (line 7, 8). There is a pause before Kate says that it looks nice and that she was picturing something else (line 10, 11). The girls take a closer look at some of the pictures they found (line 12, 13, 14, 15, 16, 17, 18). Kate wonders if this really is houses made of straw, and concludes that it is, because the text under the picture says so (line 20). Claire is also watching the pictures together with Kate and Linda. The girls are discussing the appearance of the house and are comparing the material to things they know, such as brick and concrete (line 23, 24, 25, 26, 27, 28, 29). The students end up using straw bale as structure for their house.

In this excerpt, we see some of the same dynamics as in the excerpt before. The first point I would like to emphasize is how the students base their decision on information they find moving outside the learning environment, together with information provided by the simulator. The second point I would like to mention relates to how the students when they are finding pictures, are mostly concerned with the aesthetics of the houses, and that it differs from what they expected.

We have now seen two excerpts where the students are working with the simulator, finding materials for their CO2 friendly house. In the following excerpts, they have moved on to the second last part of the project where they are supposed to write up their final products.

5.1.4 Setting 4: "Making the presentation and report"

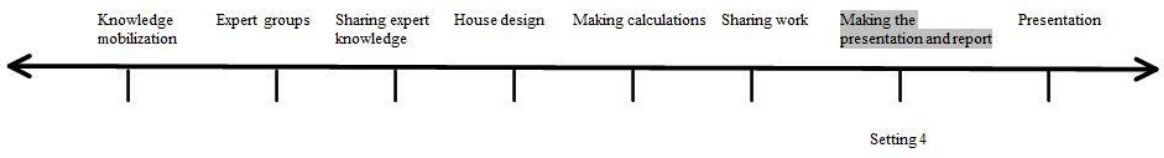

Figure 11: Project timeline, setting 4

Now, the students have entered the second last part of the project (Figure 11). They are going to make a presentation to be held for the rest of the class, and a written report to be handed in

at the end of the project. The reason why I chose these excerpts is because they show how the students' orientation changes as they are coming closer finishing project.

In these two excerpts, the students have started to talk about and plan the presentation. All four are sitting together around a table, with their laptops in front of them. We meet the students as they are talking about how they should arrange the presentation, becoming more concerned with its contents.

Excerpt PP4a

1.	Linda:	How should we set up the presentation?
2.	Claire:	I don't know, but I think that if we write a type of report that is quite extensive, we can make the presentation from that
3.	Linda:	We can do that
4.	Claire:	I think so
5.	Linda:	But should we include = Is the presentation mainly about how we made a CO2 friendly house, or is it somehow= Or what we have learned
6.	Claire:	It's what we've worked with
7.	Rachel:	It's our house, sort of
8.	Claire:	Just our house= We'll try to sell our house, then
9.	Linda:	Yes
10.	Rachel:	Why have we done this and why we have--
11.	Claire:	Why is our house good, sort of
12.	Linda:	Is that what we should do?
13.	Kate:	It's cool
14.	Rachel:	M: Yeah
15.	Linda:	Okay, but then we almost should split it up, then
16.	Claire:	Yes, but I think we really= First, we should be done with everything, and then take the presentation afterwards somehow
17.	Linda:	Yes, okay
18.	Claire:	I- I don't know= Just that I'm thinking that maybe=
19.	Rachel:	It doesn't really matter, though
20.	Kate:	It depends what you are keen on
		[The girls read about what the report should contain and what should be included. They are also beginning to talk about the goals of the house]

The excerpt starts with Linda asking how they should arrange the presentation (line 1), and Claire suggest that they write the report first and make the presentation based on that (line 2). Linda is not sure about what to include in the presentation (line 5), and Claire and Rachel tell her that the focus is what they have worked with and their house (line 6, 7, 8). Rachel adds that they have to give reasons for their decisions (line 10), and so does Claire (line 11). Based on their answer, Linda states that they should divide the work between them (line 15). Claire suggests that they should finish everything, and then work with the presentation (line 16). Rachel and Kate add that it does not matter much how they do it (line 19, 20).

The main point I want to emphasize from this excerpt relates to how the students' orientation seems to change in this part of the project. They become more focused towards their end product, namely the presentation, and what it should include. It is possible to see how they are aware of the expectations and requirements: they know that they have to present their work both in a presentation and a report, as well as they have give reason for their choices. This awareness becomes visible as the students discuss what they should do and how.

After the students have been discussing the contents in their presentation, they move on to talking about how they should go about presenting their project.

In the following excerpt, the students are talking about how they should present their project to the rest of the class. Also in this excerpt, they are sitting together all four, with their laptops. Claire has just come up with a suggestion on how the presentation will take place and what order things should be presented in. Now, she asks the others students what they think.

Excerpt PP4b

1.	Claire	But, what do you think about something like that?
2.	Kate	Yes
3.	Linda	Yes
4.	Claire	That we have such a kind of presentation?
5.	Linda	But do you have the= That one--
6.	Kate	I can place the gym equipment [Laughs]
7.	Claire	M: But it's perhaps easiest if one of you then, kind of= Has worked mostly with the emissions and the material= If you present it= Or that you kind of present it together
8.	Kate	Yes
9.	Linda	Yes
10.	Claire	So maybe we could present the layout and stuff then [Addressed to Rachel]
11.	Rachel	Yes
12.	Kate	Mhm
13.	Claire	And what we've thought about it
14.	Linda	And then I take the solar cells and Rachel heat pumps
15.	Claire	Yes
16.	Linda	Isn't that the most logical?
17.	Claire	Yes, and then we can take= But I do not know whether we should present solar panels and heat pumps, how it works
18.	Rachel	No, I don't think so [The girls turn to researcher to ask]

In the opening of the excerpt Claire asks the other students what they think about her suggestion concerning how the presentation shall take place, and the order for things to be presented. Kate and Linda agree, and Kate suggests that she can place the gym equipment (line 6). Claire suggests that each of them can present the topics they have worked with (line 7, 10). Linda follows up on Claire's suggestion, by proposing what she and Rachel could

present (line 14, 16). Claire wonders if they are supposed to present how solar panels and heat pumps function (17), and Rachel does not think so (line 18).
As in the excerpt above, I would first like to drawn attention to the students' orientation changes towards the end product and to get the task done. The students are focused on dividing the tasks between them, in contrast of working collaboratively like earlier in the project. A second point relates to how all four group members are participating, and decisions are made jointly.

5.1.5 Summing up Power Puff

We have now seen excerpts of Power Puffs' interactions from four different parts of the project. Overall, the students seemed to be attuned to each other, as they were focused on each other's understanding, worked together and made joint decisions. I will in the following sum up the interaction trajectory of the group, with focus on the main points and characteristics of the group's interaction and collaboration.

One of the main characteristics relates to how the students invited themselves and each other into the conversations, by asking explicitly whether the others understand, and by asking questions and for elaborations. This can be seen in setting 1, where the students presented their topics from the expert groups. In this setting, the students brought in a resource in form of a model into the interaction, and it became a resource in the students' sense making of the scientific concept. Another main characteristic concerns how the students made joint decisions, often formulating their utterances as questions. The students moved outside the provided learning environment in order to gather more information before making a decision. An example of this can be found in setting 3, where the students discussed the materials they found in the simulator, and searched online for more information. The information they found was used in order to make a decision, both for insulation and house structure. Another important point concerns how the students' orientations seemed to change when they came to the second last part of the project. They became more focused on finishing their end products, and adjusted to the requirements and expectations. Also, they divided the tasks between them, in contrast to working collaboratively like they did in the earlier parts of the project.

5.2 Thumbs Up

In the following, excerpts from the interaction trajectory of the group Thumbs Up will be presented. The group consisted of two girls and two boys: Jane, Lisa, Tom and Jack. During the project, they were sitting together with their laptops. The students shifted between working in dyads, working individually and working together all four a few times. Through the project, the students seemed to be oriented towards being efficient and moving on with their tasks: to design the house and make the presentation and report.

5.2.1 Setting 1: "Sharing expert knowledge"

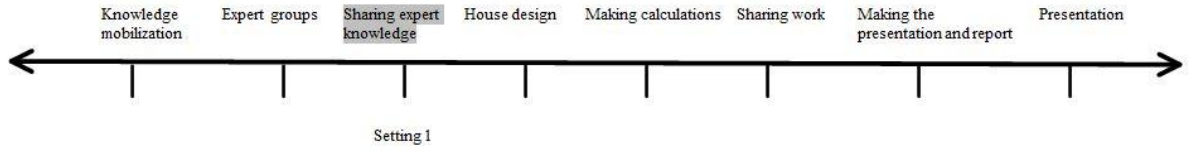

Figure 12: Project timeline, setting 1

In the following two excerpts, we see two of the students in the Thumbs Up group presenting their topics from the expert groups they were part of (Figure 12). The reason why I chose these excerpts is because they give an insight into characteristics of how the students in Thumbs Up talked about scientific concepts.

In the following excerpts, the students in the group Thumbs Up are back from their expert groups and are presenting their fields of expertise. They are sitting together all four around a table, with their laptops in front of them. In the first excerpt, Jack is telling the others about the photoelectric effect in solar panels. He has a document from the expert group on his laptop screen, and is watching this occasionally as he speaks.

Excerpt TU1a

1.	Jack:	Yes, I am the expert on solar cells. Solar cells are made of silicon plates, which are then doped with boron and phosphorus. This means that you mix in a tiny bit boron and phosphorus. [A student from another group interrupts them with a question.]
2.	Jack:	Yes, it means that they get some boron and phosphorus in it and it makes them able to conduct electricity, which means they then get the properties they need for a solar cell. You will then have a positively charged type, and a negative charge type directly over each other, also in the border area where they are in a sense drawn to each other, and it becomes a barrier, and none of them can go= U:m none of the electrons can go up or down. U:m: Yes, and then the sun's rays comes into the picture, which shines through, which then releases an electron in both plates, but it goes from the bottom plate up to the top, but it is not able to come down again, so it must

		take a detour, and this is through a wire that turns to electricity
3.	Jane:	[Nods] fancy
4.	Jack:	So= So then you can also daisy solar cells, which then allows greater voltage, and then if you have two solar cells, and= or 24 cells of 0.5 volts= Watts, I mean [Laughs] You get a voltage of 12 volts, with the parallel connection, you only increase the effect, so unless you have solar panels at 100 watts and are parallel connecting the= Or two solar cells of 100 watts and parallel connect it and you will then, you will still have a voltage that is similar, but you get a double effect, and then in a way--
5.	Tom:	Like connected in series, or am I misunderstanding now?
6.	Jack:	No, U:m, of course, I'm a bit tired now, but u:m, serial connection provides greater power when the voltage doubles all the time
7.	Tom:	You don't get watt?
8.	Jack:	No, watt stays the same
9.	Tom:	Yes
10.	Jack:	But with a parallel connection you increase the effect, so the voltage will be the same, while the effect becomes larger (.) [Jack looks at Jane]
11.	Jane:	Me?
12.	Jack:	Yes [Jane starts to present her topic]

In the opening of the excerpt Jack starts out telling the others about solar cells (line 1, 2). During his explanation Jane (line 3) nods and says "fancy", and Jack continues his explanation. Tom asks Jack for a confirmation (line 5), and Jack stops and explains that he is tired, and then he corrects himself in accordance to what Tom's question (line 6). Tom asks for another confirmation of his comprehension (line 7). Jack confirms and finishes (line 10). There is some silence, and then Jane asks if it is her turn to present (line 11).

There are some main points from this excerpt that I would like to highlight. The first point concerns how Jack involves the other students in his presentation. He is not inviting them directly into the conversation by stopping and asking them whether they understand or follow him. He pauses when the other students takes initiative and contributes with points for confirmations, and he answers. The second point relates to how the other students are participating as Jack presents. As we can see, Tom is contributing with some points for confirmation of his comprehension. The students are not being explicit on whether they understand or not. Both the comments from Jane and Tom seem to be perceived by Jack as encouragements to continue the presentation. The third point concerns how the students are presenting their expert knowledge without bringing other resources into the interaction. The fourth point relates to how the students seem to be oriented towards being efficient. They are going through the presentation of expert knowledge without elaborating and discussing the topics any further.

In the following excerpt, it is Jane's turn to present her topic from the expert group she participated in. The four students are still sitting together with their laptops. Like Jack, Jane also has a document on her laptop screen. Her topic was energy sources and she is about to tell her group members about wind power and wind mills.

Excerpt TU1b

1.	Jane:	So I don't know= Should I just tell you a little about the sources we have found out about?
2.	Jack:	You don't need to take everything, but=
3.	Jane:	No, u:m, wind power is= You know how it works, it's these big fans= [Shows with her hands] So--
4.	Lisa:	Windmills perhaps
5.	Jane:	Windmills, u::m, where= The energy that is created will be converted into electricity in a generator. U::m, and water power is what we have most of in Norway, or= And it is water that goes into a turbine, so it's like that, Yes= then there is solar energy that was what you talked about, u:m bio power, that's when you light bio energy= I think= U:m like that if you set waste wood on fire and the steam is converted into energy, isn't it so?
6.	Jack:	Yes
7.	Jane:	Yeah [laughs]
8.	Jane:	Salt power, u:m, I don't know what that is really. Also, there is something called ocean warmth, and that is to use temperature differences in the ocean to generate electricity. U:m, also the wave power, but that's how you use= And tides and stuff, but it's a bit controversial concerning how well it really works, and how much energy you really get out of it, because it's fairly new technology. U::m, but it's either= Yes, it's kind of= It's a bit like that= Also it does not work everywhere, but you can look at a picture I found, we'll see where it's= It kind of shows where the different= When you have tides and stuff, and how to use it
9.	Jack:	But it's sort of two types of tidal power plants
10.	Jane:	Mm (.) [Turns the screen for all to see the picture] Here you see sort of where the wave potential is, but one does not know how well it works because it is difficult to extract all the energy from the= But it is much more stable
11.	Tom:	Is it where it is windy?
12.	Jane:	U::m, yes, what is said was that= What was it that I wrote= It has nothing to say = It's much more stable than other
13.	Lisa:	Mm
14.	Jane:	U:m= M:::: yes, now I don't know if everything I've written is here
15.	Jane:	But, the deal is certainly that wave power is there all the time, in relation to the wind, or things that are not as stable, or solar cells, and such things, this is much more stable, although they have not figured out quite how to do it
16.	Lisa:	M:
17.	Jane:	U:m= Kate also found out a little about nuclear power, but, I haven't figured out that much more really
18.	Lisa:	Thanks
19.	Jane:	Yes

In the opening of the excerpt Jane asks the other three group members if she should tell them about the energy sources they talked about in her expert group. Jack answers that she does not

need to cover everything they talked about in her expert group (line 2). Jane starts to talk about wind power, and adds "you know how it works" (line 3) and shows with her hands, adding that there are these big fans. Lisa elaborates in line 4 with adding "windmills, maybe", as Jane only calls it "big fans". Jane confirms and continues to talk about how windmills work (line 5). During this explanation, she uses the phrases "I think" and "isn't it so?" and is seemingly signalizing two things: that she is uncertain, and that she is inviting the others into the conversation. Jack is the only one who responds verbally, with a confirming "yes" (line 6). Jane mentions salt power, and adds that she does not really know what that is, continuing with ocean heat and wave power. She talks about wave power and tide, saying that it is uncertain how well it works and the technology is quite new. In the end of line (8) she says she has a photo which shows where the tides are, and how to use it. Jack says that it is two types of tidal power plants (line 9), as an answer to Jane saying that she does not really know what it is and her explanation (line 8). Jane answers with an "mm" (line 10) and shows the others the model where they can see "where the wave potential is", adding that it is uncertain how well it works although it is more stable. Tom asks (line 11) if it is where it is windy, referring to the locations of the tidal power plants on Jane's model. Jane looks at what she wrote and answers that it does not matter and repeats that it is more stable (line 12), while she keeps looking at what she had written down (line 14). She sums up (line 15) and concludes that wave power is always present compared to wind power, it is more stable, although "they" have not figured it all out. In line 17, Jane is about to finish and tells that what another member of her expert group focused on, and adding that she did not find anything more than what she has presented to them. The excerpt ends with Lisa thanking her (line 18).

From this excerpt, there are some main points I would like to draw attention to. The first point relates to how Jane presents her topic form the expert group. She expresses her uncertainty about the topic she is presenting. By saying "I think", "isn't it so?" and saying that she does not really know what salt power is, she is signalizing that the information she presents might not be reliable and is inviting the other students into the conversation. Jack's comment in the beginning of the excerpt where he says that she does not need to "take everything" may also contribute to her uncertainty about how to present the topic to the other students. She responds to his comment by saying that they already know how wind power works. Also, she introduces a model where they can see "where the wave potential is", but this does not lead to the conversation into a different turn. The second point concerns how the other students respond to Jane's way of presenting the topic, and her invitation to take part and also correct

her if she is wrong. The students does not offer Jane elaborations or explanations, rather, they answer in form of confirmations and clarifications. The students do not ask for explanations, neither are they explicit about whether they understand or not. The third point I wish to highlight is how the students like in the excerpt before, seem to be oriented towards being efficient. It may be that they are focused on the next task, which is to get started on their design of the house. As we can see, both excerpts where the students in Thumbs Up share their expert knowledge is characterized by the students presenting their topics, while the others are taking relatively little part.

We have now seen two excerpts from the setting where the students presented their topics from the expert groups they participated in. In the following, the students have moved on to another part of the project where they are going to plan and design their CO2 friendly house.

5.2.2 Setting 2: "House design"

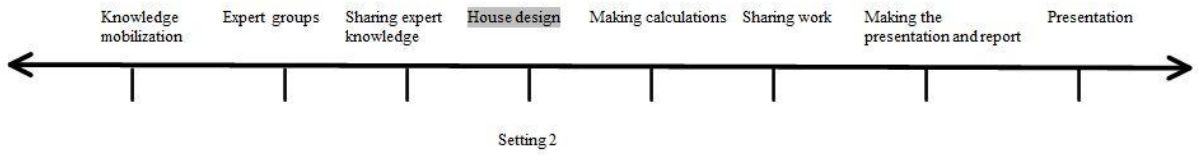

Figure 13: Project timeline, setting 2

In the following three excerpts, the students have started to plan and draw their CO2 friendly house (Figure 13). Their final house drawing can be seen in Figure 14, and was made with Google SketchUp. I have chosen the two first excerpts because they give insight into how Thumbs Up orient and plan their work. The third excerpt is chosen because it shows one of the few times that one of the girls in the group challenges the boys on their opinions and decisions.

Figure 14: Students' house drawing, made in Google Sketch Up

The students are sitting together all four, two on each side of the table with their laptops. In the following excerpt, we meet the students as they are planning how to start with the design of the house.

Excerpt TU2a

1.	Tom:	I would like to make the drawing on paper first and then make partitioning and stuff, because then we can see about how= Or should we not do so? Is it perhaps a little too advanced?
2.	Jane:	That's up to you
3.	Jack:	Heh
4.	Lisa:	Yes
5.	Jane:	What do you think?
6.	Tom:	Uh, no--
7.	Jane:	If we are to present this to the class, it's cool if we have partitioning and stuff like that
8.	Tom:	Mhm
9.	Jane:	You know what I mean? We are supposed to present this for the class
10.	Tom:	Our whole class or that class? [pointing to someone else in the same room]
11.	Jane:	I don't know
12.	Jack:	That class [points] I think it is that class
13.	Jane:	And then we'll get a grade, don't we?
14.	Jack:	Yes
15.	Jane:	Yes. Then is it cool if we have partitioning
16.	Jane:	It is
17.	Tom:	Then we do it

In the opening of the excerpt Tom is telling the other three group members that he would like to draw the house by hand with partitioning, and asks the others what they think (line 1). Jane answers that it is up to Tom, and she adds that it would be cool to have partitioning if they are supposed to present their work to the class (line 7). Jane asks if they are getting grades on

their work, and Jack confirms (line 13, 14). Based on this, Jane concludes that it would be cool to have partitioning (line 15). Tom agrees and the decision is made (line 17).
The decision to draw the house with partitioning is made, and in the following excerpt we meet the students as they are about to decide how to arrange the work they have agreed on doing. They are still sitting around a table, the girls on one side, and the boys on the other. As we have seen, they have decided to draw the house by hand, with partitioning. Now, they are discussing how to divide the tasks.

Excerpt TU2b

1.	Tom:	Will you help me with it, or are you going to do something else? [Addressed to Jane]
2.	Jane:	We can work with the house together
3.	Lisa:	Yes
4.	Jack:	What= What do we do?
5.	Jane:	You are going to fix the insulation and stuff= Cannot= You sit on one side and we on the other [pointing to herself and the two others]
6.	Lisa:	Who are we and who are you? [Jane points again]
7.	Lisa	Okay
8.	Jane	Since you have the SCY program
9.	Lisa	Can't you just come here, then? [to Jack who she will work with] [The students move and sit together in dyads]

The excerpt starts with Tom asking Jane if she would like to help him draw the house, or if she is going to something else (line 1). Jane answers that they can do it together, and Jack wonders what they (he and Lisa) should do. Jane tells him and Lisa to "fix insulation and stuff" (line 5), and suggests that they should sit together. Jane adds that Jack and Lisa have "the SCY program", as a reason for her suggestion (line 8). The students divide into two dyads.

There are some main points I wish to emphasize from these two excerpts. The first point concerns how the students relate their work and how to design their house in accordance to whether or not, and how their work will be evaluated. They base their decision about the drawing on the fact that they will be graded and are to present their project. The second point relates to how they seem to be oriented towards being efficient and getting on with the task to design their house.

The students work for a while in the dyads they agreed on above. After a while, the boys take over the drawing of the house, and the girls work with other tasks related to the simulator and the presentation and report. In the next excerpt, the boys are working on the drawing of the house with partitioning, on their laptops with the drawing tool Paint. The girls are working on

the presentation and report on their laptops. Then Jane takes a look at the drawing on Jacks laptop. She discovers that they have made changes on the drawing that she made earlier.

Excerpt TU2c

1.	Jane:	What have you done? [addressed to Jack and Tom, pointing to Jack's laptop screen, showing the drawing of their house with partitioning]
2.	Tom:	Uh, that is--
3.	Jack:	It's the second floor= We use it in a way--
4.	Jane:	Why have you left= Uh, made such strange rooms? (.)
5.	Tom:	How?
6.	Jack:	Because it is most efficient--
7.	Jack:	It's a environmental friendly house= It's <u>not</u> pretty [laughs a little] [Tom and Jane laugh a little]
8.	Tom:	But, hello= One can have a bed= For example= And here we have two small rooms [pointing at the drawing]
9.	Jane:	But I just wonder why= These rooms are kind of going <u>into</u> each other= That it's not well proportioned, like I did it
10.	Jack:	Because you use up half the space [Jane whispers something to Lisa, and the boys laugh]
11.	Tom:	Okay, what do you mean, Jane?
12.	Jane:	I <u>cannot</u> talk to you [laughs] [Jack and Tom laugh]
13.	Tom:	You cannot if you don't try (.) [Jane starts to talk to Lisa about the presentation]

In the opening of this excerpt, Jane asks Jack and Tom what they have done, referring to the changes they have made on her earlier draft. Jack answer that it is the second floor of the house (line 3), but Jane interrupts him and asks why he has "made such strange rooms" (line 4). Then a moment of silence follows, before Tom asks her to clarify (line 5). Jack answers that it is more efficient (6), and adds that this a environment friendly house, and adds with a little laugh that it isn't pretty (line 7). Tom and Jane laugh a little too, and Tom starts to explain to Jane what the drawing is showing (line 8). Jane wonders why the rooms are going "into each other" and states that it is not proportioned, like it was when she made it (line 9). Jack replies that her way used up half the space in the house (line 10). Jane turns to Lisa and whispers something in her ear, and the boys start laughing. Tom asks Jane what she means (line 11), and Jane answers with a higher pitch in her voice, that she is not able to talk to the boys (line 12). They start to laugh again, and Tom tries to encourage her by saying that she cannot do it if she does not try (line 13), but without luck. There is a moment of silence, and then Jane changes the subject by starting to talk with Lisa about the presentation they are working on.

There are some main points I wish to emphasize in this excerpt. The first point relates to the students orientations. Jane seems to be oriented towards how the boys have made changes on her earlier draft, without involving her or Lisa. The second point concerns how Jane asks for justifications and elaborations from Jack, regarding the drawing of the house. Like I have mentioned earlier, this is one of the few situations where one of the girls challenges the boys about their choices or opinions. The third point I wish to highlight is how the interaction comes to an end. Jane ends the conversation without closure, and returns to her work.

In the three excerpts above, we have seen how the students work with the design of their house. Now, they have moved on to another part of the project, and other activities which involves the use of the simulator in SCY-Lab.

5.2.3 Setting 3: "Making calculations"

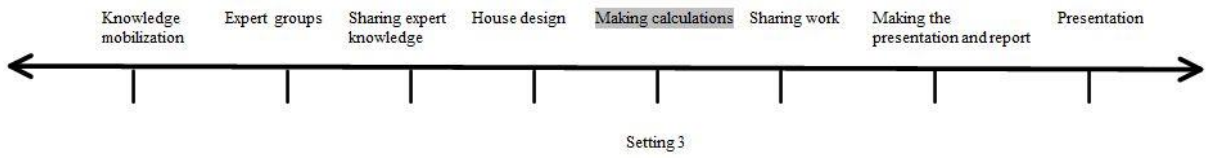

Figure 15: Project timeline, setting 3

In the following four excerpts, the students in Thumbs Up are working with the simulator and deciding on materials, finding a heat source as well as deciding on measures and values for their house (Figure 15). In order to design a CO2 friendly house, the students were supposed to find materials and calculate values that provided a satisfying heat loss coefficient and a low U-factor, namely little heat loss and solid insulation. I have chosen these excerpts because they provide insight into how this group makes decisions, and what these decisions are based on.

In the following excerpt, the students are working with a new activity, which is to decide on a material for their house. All four students are sitting together with their laptops. The girls are working with the SCY-Lab and simulator, and the boys are working with the drawing of the house. Earlier, they have talked about using wood as material, and in the following two excerpts we see how the students discuss whether to use another type of material for the house structure.

Excerpt TU3a

1.	Lisa:	Okay, should we have straw instead, then?
2.	Jane:	Guys, we are considering to use straw instead of wood, because it's= hm?
3.	Lisa:	Can you press--
4.	Tom:	Because all the others had straw?
5.	Jane:	Hm? [To Tom]
6.	Tom:	Because they all had straw? Like=
7.	Jane:	No, because it's--
8.	Tom:	Less heat emissions?
9.	Jane:	Mm
10.	Jack:	Straw as insulation, then?
11.	Jack:	Or?
12.	Jane:	No, as <structure>
13.	Tom:	Huh?
14.	Jack:	Straw?
15.	Lisa:	Yes, that's what I was wondering too= Isn't that straw house?
16.	Tom:	No, we cannot have straw as structure
17.	Jane:	But do you know how much better it is, or what?
18.	Jack:	Yes, but it's straw
19.	Tom:	There is nothing that holds it together
20.	Jack:	Yes, but--
		[The students talk about different types of material and what the other groups have done]

Lisa and Jane have been working with the simulator and found that straw may be a good choice for the house structure, as is gives the lowest emissions. Jane presents their choice to Jack and Tom (line 2), and invites the two boys to join the discussion. Tom asks if they want to use it because the other groups are using straw as material. Jane is about to answer him (line 7), but before she does, he asks if it gives less heat emissions (line 8), which Jane confirms. Jack asks if they are going to use straw as insulation, but Jane says that it is as structure. Both Tom and Jack react with disbelief and shuts out (line 13, 14). Lisa responds to the boys' expressed scepticism by saying "yes, that was what I was wondering too" (line 15). Tom rejects the proposition simply by stating "No, we cannot have straw as structure" (line 16). Jane asks them if they know how much better it is to use straw as structure instead of wood, referring to the information provided by the simulator (line 17). Nevertheless, both the boys are still negative to the suggestion (18, 19) and Tom states that it is nothing that will hold the house together, if they use straw (line 19).

The students talk about some private matters before they after a short while return to the topic whether to have straw bale as structure. In the following excerpt, we meet the students as Lisa is asking a question about the simulator, as she is looking at the numbers and bars.

Excerpt TU3b

1.	Lisa:	I don't understand= What's that? [pointing at the numbers in the simulator]

2.	Lisa:	Because if you look there, it's like= That one is better than the other
3.	Tom:	But you haven't chosen hemp as structure?
4.	Lisa:	Huh?
5.	Jane:	No, now we have wood
6.	Tom:	That's good
7.	Jack:	Okay
8.	Jane:	But= <The other> is really better
9.	Tom:	Hemp?
10.	Jane:	Mhm= <straw bale>
11.	Tom:	Eh, yes, but then there is nothing that holds it together, then
		[The students keep talking about values in the simulator, and the thickness of the walls. They end up using wood as structure for their house.]

Lisa looks at the bars and the numbers in the simulator, where they also can see the U-factor, and comments on what she sees (line 1, 2). Tom asks if they have used hemp as structure, and Jane answers that they now have wood. Both Tom and Jack approve (line 6, 7). Jane still wishes to have straw bale and states that straw is a better choice. Tom has not changed his mind either, and still argues that nothing holds the house together if they use straw (line 11).

There are some main points that I would like to highlight from these two excerpts. The first point relates to how the students make decisions, and what these decisions are based on. Jane argues for using straw bale, basing her argument on information provided by the simulator: straw bale shows the best CO2 calculations. Still, boys disagree with her choice of material. They seem to base their arguments against straw bale on their personal opinions, and Jane gives in. The students end up using wood as structure for their house, and not straw bale, and consequently choose to disregard the information given in the simulator. The second point concerns how the students do not move outside the learning environment in order to obtain more information about straw bale as house structure.

We have now seen the students discuss what material to use for their house structure. In the following, they have moved on to discuss what type of heat sources to use in their house.

They are sitting together all four, and Jack is telling the others about briquette ovens and heat pumps using his own experience as point of departure.

Excerpt TU3c

1.	Jack:	No, but= Such briquette ovens, they= They can if you take it out properly= Warms up water, and the water going around in the radiator warms up the whole house
2.	Jane:	Smart
3.	Tom:	And warms up the water?
4.	Jack:	Warms up water, yes= So you get hot water, half enough=
5.	Tom:	So we should have a giant briquette oven and a giant heat pump

6.	Jane:	Where should the heat pump--
7.	Jack:	We don't need briquette oven and heat pump, that's a bit over kill= [Laughs]
8.	Jack:	But briquette ovens and heat pumps does the same, it's just two different technologies
9.	Tom:	Yes
10.	Jack:	You get the same result= So the question is really just whether to drill 100 meters into the ground= Or we should have [inaudible]
11.	Tom:	We can have the briquette oven outside, then
12.	Jack:	Yes, really= Terrestrial heat is much more efficient (.)
13.	Tom:	We do that, then
14.	Jane:	We do what?
15.	Tom:	Then= Drill= We drill down
16.	Jane:	We drill down
17.	Jack:	My neighbour did that= Drilled 90 meters down [There is silence, and the students turns their attention towards their laptops]

Jack starts out by telling the others that briquette ovens can be used to make hot water (line 1, 4). Tom suggests that they should have a giant briquette oven and a giant heat pump (line 5), but Jack dismisses him and says that it would be "overkill" (line 7). Jack adds that briquette ovens and heat pumps have the same purpose, but they are different technologies (line 8). Tom confirms (line 9), and Jack keeps going with his explanation, saying that it is a question whether they should drill hundred meters into the ground (line 10). Tom suggests that they could have the briquette oven outside (line 11), and Jack answers that terrestrial heat is more efficient (line 12). There is a moment of silence, before Tom says "we do that, then" (line 13), and Jane answers "we do what?" (line 14). Tom says that they will drill down (line 15), and Jane agrees to his suggestion by repeating "we drill down" (line 16). Jack adds that his neighbour "drilled ninety meters down" (line 17).
The students move on to another task, and start working with the simulator, setting measures and values for their house.

All the four students are sitting together with their laptops. Jane and Lisa are working with SCY-lab and the simulator, checking different measure and values. The girls are concerned with getting the bars in the simulator as low as possible. In the following excerpt, the students are discussion the measures of the walls and insulation for their house.

Excerpt TU3d

1.	Jane:	Yeah, but what= Where= We cannot have 30 cm thick--
2.	Lisa:	Mhm= It's 50
3.	Jane:	If we have 50
4.	Lisa:	Don't you think that it's a bit too much wall?
5.	Tom:	A lot of wall? 50 cm? Outer walls are not very--
6.	Jack:	It's not that much, really

7.	Lisa:	I just imagine that it's a lot (.)
8.	Lisa:	I don't understand any of this= It is <u>way</u> too difficult
9.	Jane:	That, this was pretty smart [commenting on what she is doing in the simulator]
10.	Jack:	So thick
11.	Jane:	Heh, we have 40 cm of insulation and 10 cm with wood
12.	Tom:	You, Lisa, it's the wall = It's not that thick
13.	Tom:	Or, yes, it's perhaps a bit thick= This would perhaps be enough
14.	Lisa:	Are we going to have such a thick wall?
15.	Jack:	Yes, but we aren't making a ordinary house= We are making a environment friendly house
16.	Tom:	Huh
17.	Jane:	[Laughs] yeah, exactly
18.	Lisa:	Hah, environment friendly houses are not like other houses
19.	Jack:	So when can we have some thick walls
20.	Lisa:	Yes, okay
21.	Tom:	And it's lot easier to draw
22.	Jack:	[Laughs]
23.	Lisa:	Yeah
		[The students agree on having 50 cm thick walls, saying that an environment friendly house is not like an ordinary house. Later in the day, both the teacher and one of the researchers come by and look at the students' measures. Both tell them that the measures are unrealistic and that they should change them. Also, the students are reminded of the fact that they are supposed to give reasons for their choices both in the presentation and in the report. The students do not agree at first, but as they reach the fourth and last day of the project, they decide to change the measures into something more realistic, based on what they were told by the teacher and researcher.]

In the beginning of the excerpt, Jane argues that they cannot have walls which are 30 cm thick (line 1). Lisa says that it is 50 cm, and asks the others if they think that it is too much (line 2, 4). Tom and Jack answer that it is not that much (line 5, 6), and Lisa reasons that she is imagining it to be a lot (line 7). The students are silent for a short while, before Lisa says that she does not understand anything and that it is too hard, talking about SCY-Lab (line 8). Jane comments on what she is doing in the simulator, saying that it is smart, and that they now have 40 cm with insulation and 10 cm with wood (line 9, 11). Tom talks to Lisa and says that the walls are not that thick, before he reconsiders and wonders if less would be enough (line 12, 13). Lisa asks if the wall is going to be that thick (line 14), and Jack reasons that they are not supposed to make an ordinary house, but an environmental friendly one (line 15). The others respond and Jane says that environmental friendly houses are not like other houses. Jack concludes that because of this, they can have thick walls (line 19). The others agree, and Tom says that it makes it easier to draw (line 20, 21, 22, 23).

In these two excerpts, we see some of the same dynamics as in the two excerpts 3a and 3b. Firstly, I would once again like to draw attention to how the students make decisions and

what these decisions are based on. In excerpt 3c, Jack is telling the other students about briquette ovens, and bases his opinion on personal experience, namely what his neighbour did. The other students listen to and agree with Jack's suggestion to use heat pump and to "drill down". In excerpt 3d, the students also seem to base their decision on their personal opinions, this time concerning the measures on the walls of their house. The second point concerns how the students are not moving outside the learning environment in order to bring in other resources into the discussions about heat sources and measurements. The third point relates to what we see in excerpt 3d, how the students are focusing on getting the bars in the simulator as low as possible, and they dismiss the possibility that their measures may be unrealistic. Also, they are concerned with the drawing of the house.

In the four excerpts above, we have seen how the students worked with deciding on material for their house, finding a heat source and as well as finding measures and values for their house. In the following, they have moved on to the second last part of the project.

5.2.4 Setting 4: "Making the presentation and report"

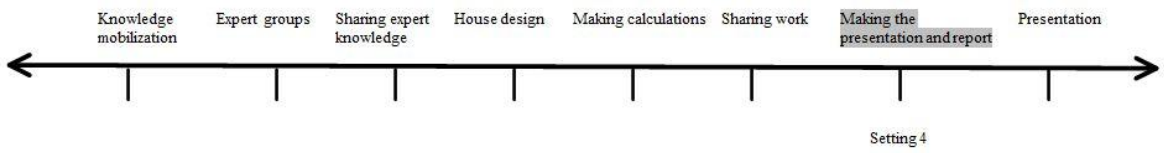

Figure 16: Project timeline, setting 4

In this part of the project, which was the second last, the students worked with their end products, which were a presentation to be held for the rest of the class, and a written report to be handed in at the end of the project. I chose the following two excerpts because they provide an insight into how they are oriented towards the fact that they are being evaluated, and how they share the tasks between them.

In the following excerpt, we meet the students as they are sitting together all four, and are planning what to do next. Jack and Tom are focused on their drawings of the house, Lisa and Jane are writing on the presentation and the report.

Excerpt TU4a

1.	Jack:	But maybe we should do the draw— Do all the drawings of the house again= Kind of?
2.	Tom:	Again?

3.	Jack:	Yeah, doing it properly-- Three drawings, three sheets=
4.	Jane:	But= Can't you= Listen= I and Lisa have a great idea= I write the presentation, she writes the report, and the two of you work with--
5.	Jack:	Drawing the house
6.	Jane:	Yes, but= And place the heat pump and stuff like that= Give us an explanation so that we can write why we have chosen to do as we have done
7.	Jack:	Ye:s
8.	Tom:	Ye:s
9.	Jane:	Smart? Yes
10.	Jack:	And we have--
11.	Lisa:	They are going to write why we have done as we have?
12.	Jane:	Yes, but only= Give us a brief explanation so we can write it
13.	Lisa:	Yes yes yes
14.	Tom:	Do we have to draw it all again?
15.	Jane:	It's a very good question, really
		[The teacher comes by and tells them what will happen the next time they are working on the project]

During the project, Jack and Tom have mostly been concerned with drawing the house, first by hand, and then in Google SketchUp. They have been accurate and spent much time in order to get the right measures. The sequence begins with Jack proposing to draw the house again (line 1). Tom repeats Jack's question by saying "again?" (line 2), and Jack confirms, adding "doing it properly" (line 3). Jane answers saying that she and Lisa have a great idea (line 4), telling the boys what Lisa and herself are doing, and is about to tell the boys what to do when Jack interrupts in line 5: "drawing the house". Jane tries to get her message through and responds in line 6 "yes, but", and then she asks them to place a heat pump and "stuff like that" and give them an explanation so they can "write why we have chosen to do as we have done". Neither Tom nor Jack seems particularly enthusiastic about the tasks they are assigned (utterance 7, 8). Lisa asks if it is the boys who are going to write "why we have done as we have", and Jane says that the boys will only give an explanation, they will write it themselves (line 12). Tom asks again (line 14) if they have to do the drawing again. Jane replies that it's a good question.

From this excerpt, I would like to draw attention to students' orientations. Jane seems to be focused on the end product, in form of their presentation and report. By suggestion what the boys can do instead of drawing the house once more, she seems to be focused on getting the work done. Also, she is adjusting to the requirements and expectations within the school setting, as she is acknowledging the fact that they have to give reasons for their choices in the presentation and report.

The students have been working with their presentation for a while, and now they are planning who will say what, and sharing what they have written down so far. Like before, all four are sitting together with their laptops. In the following excerpt, we meet the students as they come closer to finishing their end product and Jane asks the others about the division of work.

Excerpt TU4b

1.	Jane:	Who is going to write that "the house has two floors" and stuff like that?
2.	Tom:	Can't we just have a= Can't we just divide the introduction?
3.	Lisa:	Hm, that's what I am supposed to write about [interrupts Tom]
4.	Jane:	Yes, sure we can [Speaking low]
5.	Jack:	But I don't have very much to say really= Really, I'm talking= Talking about the outside of the house= And it's not much
6.	Lisa:	But I started to write that the last time= I just= It was so much fuzz yesterday that I was totally crazy
7.	Jane:	[Laughs] But what was I about to say= Because you can talk about the things I've written= Eh, you can= I've only written like short, about the front door, also, whether you should say something about the windows= That they are triple glass windows = And that windows consists of 40% of the heat loss, triple glass will reduce heat loss significantly and stuff like that
8.	Jack:	Yes
9.	Jane:	Because you can say that= Because it is kind of nothing=
10.	Lisa:	Huh? I have written= Just listen now, I'll read [Lisa starts to read what she has written]

In the opening of this excerpt, Jane asks the other three who is supposed to write one of the parts/sections in the report (line 1). Tom asks why they can divide it in the introduction (line 2), and Lisa says that she is supposed to write it. Jack tells them that he does not have a lot to say, only something about the outside of the house (line 5). Lisa informs them that she has started on that, but hesitates and says that it was a lot of fuzz yesterday. Jane cuts through (line 7) and tells Jack that he can present some of the things she has written about the doors and windows. Jack agrees and Lisa starts reading out loud what she has written.
The main points I wish to highlight in from this excerpt, concerns the students' orientations. They seem to be focused on getting on with the task to finish their end products, and are talking about how this can be done. They are dividing tasks between them, like they have done earlier in the project. In addition, it is possible to see how the students are adjusting to the requirements, as they are aware of the fact that they are supposed to give reasons for their choices.

5.2.5 Summing up Thumbs Up

I have now gone through excerpts of Thumbs Up interaction trajectories from four different parts of the project. Overall, the students seemed to be oriented towards being efficient and moving on to designing the house and to make the presentation and report, which may have been what they comprehended as the most important tasks. In the following, I will sum up the interaction trajectory of the group, with focus on the main points and characteristics of the group's interaction and collaboration.

One of the main characteristics concerning Thumbs Up relates to how the students did not invite themselves of each other's directly into the conversations, by asking questions or for elaborations. This can be seen in setting 1, when the students presented their topics from the expert groups. Rather, they contributed to each other's presentations with answers in form of confirmations or clarifications. Other resources were to a little extent brought into the interaction. The students seemed in setting 1 to be focused on moving on to the next task, which was to design the CO2 friendly house. Another main characteristic relates to how the students made decisions. At one point, a decision was made based on whether or not, and how they would evaluated, as seen in setting 2. When making decisions about their house, the students did not move outside the provided learning environment in order to obtain more information. Their decisions were mostly based on their personal experiences, and what they thought would be best. For instance, this can be seen in setting 3, where the students end up dismissing the information about straw bale as structure provided by the simulator. Also, the students were concerned with getting the bars in the simulator as low as possible, and dismissed the possibility that their measures may have been unrealistic. When they were finished with the design of the house, the students were focused on the end product: the presentation and report. In setting 4, it was possible to see how they adjusted to the requirements and expectations as they were aware of the fact that they were supposed to give reasons for their choices.

6 Discussion

The overall focus of this thesis is to study students' collaboration when engaging with the computer-based inquiry environment SCY-Lab within the setting of school. According to the sociocultural perspective it is in interaction with others that individuals are making sense of words and concepts, and negotiating shared meaning. Therefore, it is central to study collaboration as this gives access to and a better understanding of the students meaning making process.

In the following part of the thesis, I will discuss the findings from my empirical study focusing on the similarities and differences in the two groups' way of working collaboratively, in order to answer my research questions. I will elucidate my findings using theory presented earlier in this thesis, together with relevant findings from the studies I have reviewed. In order to be able to discuss the term collaboration, I have chosen some indicators which will function as guidelines when I discuss the similarities and differences of how the two groups work together when engaged with the computer-based inquiry environment SCY-Lab. Related to my first research question, I have chosen to focus on what distinguish the students' talk; how they make decisions, what these decisions are based on, and how they go about talking about scientific concepts and phenomena. Related to my second research question, I have chosen to focus on how the students comprehend and make use of the given technology and other digital tools in their collaboration. Related to my third research question, I have chosen to focus on how the situated and contextual factors of the school setting come into play in the students' collaboration.

Firstly, I will discuss the meaning of language in the students' collaboration and meaning making process when working with SCY-Lab. Secondly, I will discuss how the students comprehended and made use of the given technology in their collaboration, in light of mediation and artefacts. Thirdly, I will discuss the situated and contextual features of the students' collaboration.

6.1 Collaboration, language and meaning making

As presented earlier in this thesis, within the sociocultural perspective language is seen as "the tool of tools" for social interaction (Cole, 1994). According to the sociocultural

perspective, individuals negotiate and make sense of words and concepts in interaction with others, and language is seen as a crucial mediating tool for this meaning making process. According to Linell (1998), individuals are shaping the structures of discourse through collaboration. This implies that those interacting are guiding each other through the dialogue, and shaping it. The collaboration in dialogue helps individuals to demonstrate a shared experience and meaning. Lemke (1990) claims that a word in isolation only has a meaning potential, which implies that it may contain several possibilities and mean various things. More exact meanings and interpretations are negotiated by individuals in interaction with each other. This means that the meaning potential of scientific words and concepts are created in collaboration between the students. Also, the negotiated shared meaning is related to the context, which here is the institutional setting of school. There are common ways of talking about a subject, and the students working with scientific words and concepts may have a conception of these authorized versions of the concepts used. Although, they still have to negotiate a shared meaning within the group, which is relevant for their context and available tools.

6.1.1 Decision making and the use of information

In the earlier presented analysis, it is possible to see some differences in how the two groups made decisions. The students in Power Puff were mainly making jointly decisions where they invited each other to take part and share opinions by formulating their utterances like questions. In excerpts PP2a and PP2b it is possible to see how the students were attuned to each other when drawing the house, moving from working in dyads to working collaboratively all four with their drawing. The students in Thumbs Up differed somewhat from Power Puffs' approach, as decisions were made with fewer invitations to participate and share opinions. Based on these findings, it is possible to argue that the students in Power Puff were making their thinking visible for each other to a larger extent than the students in Thumbs Up.

In addition to which extent the students in the two groups were attuned to each other, they had different approaches in how they used information in their decision making. The students in Thumbs Up tended to use personal opinions and experiences when making decisions. An example of this can be found in excerpts TU3a and TU3b, where the students discussed whether to use straw bale as structure for their house. Jane based her arguments in favour of

using straw bale on the information provided by the simulator, and the boys in the group dismissed her suggestion and seemed to base their statements on personal opinions about straw bale as material for their house. They did not move outside the provided learning environment in order to obtain more information about the topic they were discussing. The students ended up not using straw bale as structure for their house, and this decision seemed to be based on personal opinions. In contrast, the students in Power Puff moved outside the learning environment in order to gather more information about a given topic. This can be seen in excerpts PP3a and PP3b, where the students discussed what materials to use both for insulation and structure for their house, and searched online for more information. In excerpt PP3a, it is possible to see how Kate used the obtained information in her arguments concerning insulation material, when the students were negotiating in order to make a decision. In both excerpts, the information they gathered was used in order to make a decision about the materials to use. I will return to the topic of information use later in this chapter, together with some possible explanations of why the students' approaches may have differed.

6.1.2 Discussing scientific concepts and phenomena

In addition to the students' decision making processes; it is possible to see some differences in how the students talked about scientific concepts and phenomena. When the students in Power Puff shared their expert knowledge and discussed scientific concepts, they invited the other as well as themselves into the conversation by asking questions and for elaborations. For instance, it is possible to see in excerpt PP1a how Linda were trying different strategies in order to make her peers understand, which included bringing in an everyday concept introduced by the teacher. Furthermore, the students structured their discourse in a way that opened up for making sense of the scientific concepts that they were handling, and allowed them to demonstrate a shared experience and meaning.

When discussing scientific concepts, the students in Thumbs Up did not invite each other or themselves directly into the conversation by asking questions and for elaborations to the same extent as the students in Power Puff did. Rather, they contributed to each other's sharing of expert knowledge with answers in form of confirmations and clarifications. The structure of Thumbs Up's discourse was characterized by them presenting a topic with a lesser extent of elaborations, questions and explanations compared with Power Puff. This may have

contributed to that the students did not negotiate a shared meaning of the scientific concepts to the same extent as the students in Power Puff.

In accordance with the notion of the zone of proximal development by Vygotsky (1978), it is possible to argue for the importance of collaboration with more capable peers when discussing scientific concepts and phenomena. The students in Power Puff may have functioned as support for each other as they shared and discussed their topics of expert knowledge. As they had a topic each where they were more capable than the others, they were able to guide and support each other through the different topics.

6.1.3 Three types of talk

The differences in the two groups' way of communicating can be seen in light of Mercer and Wegerif's (1999, pp. 85) three analytic categories of talk. These categories can be used for reference when understanding how students use talk in order to "think together". These three categories are "disputational talk", "cumulative talk" and "exploratory talk". Like mentioned earlier, exploratory talk is a type of talk where "knowledge is made more publicly accountable and reasoning is more visible in the talk". This kind of talk is characterized by students engaging both critically and constructively with each other's ideas. Considerations are done jointly, with offered statements and suggestions (Mercer & Wegerif, 1999).

It is possible to argue that the talk going on between the Power Puff students contained elements of what can be seen as exploratory talk, for instance when they discussed materials for their house in excerpts PP3a and PP3b, both concerning insulation and structure. In excerpt PP3a, Kate's reasoning was visible as she related it to the information she found, and Claire was engaging with her ideas. Another example of this can be found in excerpt PP3b, where Kate and Linda searched for pictures of houses made of straw bale, and they were making jointly considerations about the pictures they were viewing. In addition to this, the Power Puff's sharing of expert knowledge contained elements of this kind of talk, as they asked each other questions and for elaborations. For example, this can be seen in excerpt PP1a, where Linda was explaining the photoelectric effect in solar panels, and Claire was participating by asking questions and commenting. Exploratory talk represents a social mode of thinking, and is seen as being essential for successful participation in educational discourses (Mercer & Wegerif, 2009). Mercer et al. (2004) found in their study that talk based activities can function as support for students development of reasoning and scientific

understanding. Also, Mercer et al. (2004) argue that the development of scientific understanding is supported in the best way by a combination of peer group interaction and expert guidance. In relation to these claims, it may be that the students in Power Puff enhanced their understanding of the scientific concepts and phenomena they discussed, by collaboratively using talk that contained elements of what can be seen as exploratory talk.

It is possible to argue that Thumbs Up's interactions had more similarities to cumulative talk, which is characterized by confirmations and repetitions, and that the interlocutors build positively but uncritically on what the other group members say (Mercer & Wegerif, 2009). For instance, this can be found in excerpt TU3c, where the students listened to and agreed uncritically with Jack's suggestion to use heat pump in their house. Another example of this is how Tom in Thumbs Up was asking Jack for confirmations of his comprehension in excerpt TU1a, as Jack was presenting his expert knowledge. In addition, the analysis of the Thumbs Ups' interactions concerning both the house design and to making of calculations, indicate that the students also had some similarities to what Mercer and Wegerif (2009) describe as disputational talk. This kind of talk is characterized by disagreement and individual decision making, few attempts to use resources and to offer constructive criticism and suggestions (Mercer & Wegerif, 2009). This can be seen in excerpt 3a where the students were discussing straw bale as structure for their house. Tom and Jack did not agree with Jane on using straw bale, and they did not attempt to pool resources or to offer constructive suggestions (Mercer & Wegerif, 2009). However, the three analytic categories of talk provided by Mercer and Wegerif (2009) does not involve a focus on what the students talk about. In addition to taking a closer look at the characteristics of the students' talk and collaboration, it is necessary to pay attention to what they talk about in order to gain a better understanding of their collaboration and meaning making processes. In the following section, I will focus on the students' orientations and what they talk about.

6.1.4 The students' orientations

I have now discussed how the students in the two groups made decisions, what they based their decisions on, and how they talked about scientific concepts and phenomena. In the following, I will take a closer look at the students' orientations, and what they talked about.

During the students' sharing of expert knowledge, it was possible to see some differences in the two group's orientations. Furberg and Rasmussen (in press), describe fact orientation and

explanation orientation as two forms of orientations that can be used for reference when understanding students actions, but not as "either/or" situations. It may be reasonable to argue that Power Puff went through their presentations of expert knowledge being mostly explanation oriented, which implies a focus towards considerations, argumentations and understanding. Thumbs Up seemed to be closer to a fact orientation, as they moved through their presentations with less discussion and reflection over the scientific concepts they presented (Furberg & Rasmussen, in press). The two forms of orientations presented by Furberg and Rasmussen (in press), can be seen in relation to the relationship between conceptual and procedural orientations discussed by Krange and Ludvigsen (2008). Being conceptually oriented represents a focus towards understanding the given knowledge domain, while being procedurally oriented represents a focus towards doing the task. Students who are procedurally oriented may deal with different concepts, but they do not consider how these concepts are related to a larger conceptual system (Krange & Ludvigsen, 2008, pp. 26).

As argued above, the students in Power Puff had similarities to Mercer and Wegerif's (2009) term exploratory talk as they moved outside the learning environment gathering information. At the same time, it is reasonable to point out that they seemed somewhat fact oriented when doing so. This implies that they were generally concerned with reproducing the information they found, without much reflection or discussion. This can be seen in excerpt PP3a, where the students in Power Puff were searching online for information about insulation, and how they used the information they found without comparing it to other information sources or being critical. Also, when searching for pictures of houses made of straw bale in excerpt PP3b, the students were mostly concerned with the aesthetics of the houses, and not to discover the knowledge domain.

Through the project, the students in Thumbs Up seemed to be mostly procedurally oriented, as they were focused on being time efficient and to move on with their tasks. An example of this orientation can be seen in excerpt TU2a, where the students relate their work and how to design their house in accordance to whether or not, and how their work will be evaluated. This was also the case in the study by Krange and Ludvigsen (2008), where they found that the students was first of all focused on solving the task, and least focused on understanding the problem domain. As discussed in the review chapter, Kollar et al. (2008) presented similar findings in their study. Students receiving collaboration support when working in a Web-based learning environment became better at doing the task, but did not gain more conceptual

knowledge. Overall, the students in Power Puff were being more oriented towards the conceptual compared to the students in Thumbs Up, despite of them being fact orientated as they searched online for information. Examples of their conceptual orientation can be found in their sharing of expert knowledge. However, Power Puff's orientations somewhat changed during the project, towards being more procedural at the end. I will return to this topic later in the chapter, together with some possible explanations of why this may have been so.

Based on the findings discussed so far, it is possible to argue that the students in Power Puff were making their thinking visible, and functioned as support for each other to a larger extent than the students in Thumbs Up did. Also, we have seen that the students had different orientations during the project work, but they became more similar towards the end of the project.

6.2 Collaboration, artefacts and mediation

Although language was an essential mediating artefact for the students' meaning making process in my empirical study, they were also surrounded by physical tools and artefacts. SCY-Lab and the varieties of technology the students were using during the project were also crucial parts of their collaboration and meaning making process.

The term mediation suggests that individuals are not in direct and uinterpreted contact with the world around them (Säljö, 2004). According to the sociocultural perspective, one has to take the mediating artefacts and the social aspects into account in order to understand learning as a social activity. Like with words, artefacts may also have a meaning potential. The students working collaboratively in order to design a CO2 friendly house and using SCY-Lab were faced with the challenge to negotiate and create a shared meaning of the tool. This means that the use and meanings of the technology is created, negotiated and reconstructed by the students during interaction, as the technology is a crucial part of the meaning making process. The technology also provided the students with a structure, in a way that it may give the students clues or directions on what to be done, and what is expected of them (Furberg, 2009). Even though they are given this structure, the students still had to make sense of the task. In the following, I will discuss how the students comprehended and made use of the various resources presented to them during their work with the project.

First of all, it is reasonably to say that SCY-Lab functioned as a structuring resource for the students as they were given usernames and passwords in dyads. This meant that two and two students in the same group were given the same username and password, and was told to work together. This was due to the fact that the technology was not stable enough to have all students logged on individually at the same time. It is reasons to believe that this structured the way the students worked with the project. But even though both groups were told to work in dyads based on their usernames, the two groups did not work in dyads in similar ways. For instance, the students in the two groups differed to what extent they worked individually during the project. The students in Thumbs Up tended to divide tasks more between them, than Power Puff did. Also, the students in Power Puff worked together all four, more than Thumbs Up did.

The two student groups also differed in what seemed to be their comprehension of SCY-Lab, in addition to how the students understood the task they were given. Thumbs Up seemed to be mostly procedurally oriented during the project, and focused on doing the task, namely the drawing and making of the house, in contrast to understanding the knowledge domain. Power Puff too made drawings of their house, but they were also oriented towards understanding the knowledge domain. The analysis of the students interactions show that the students in Power Puff may have seen SCY-Lab as an open resource, where they had to obtain more information from outside SCY-Lab in order to gain a better understanding and to make decisions. On the other side, the students in Thumbs Up may have seen SCY-Lab as a more complete resource, where the combination of the information provided and their own opinions and experiences were all they needed in order to understand and to make decisions. This difference in comprehension can be exemplified in Power Puff excerpt PP3a, where the students discovered the range of choices of insulation material provided by the simulator, and decided to search for more information on the Internet, in order to make a decision. When the students in Thumbs Up were faced with the information provided with the simulator, like in excerpts TU3a and TU3b, their strategy was to use their own personal opinions and experiences in order to make a decision. As a consequence, they dismissed the information provided by the simulator, which shows that straw bale provides the best CO2 calculations. In excerpt TU3d, the students in Thumbs Up became aware of how they could manipulate the values in the simulator in order to make the bars as low as possible. This discovery made them dismiss the fact that their measures were quite unrealistic, and based their decision on personal opinions with emphasis on the low bars. Even though they used the simulator in order to make a

decision, they dismissed the measures by having a one-sided focus on the low bars. A reason for the different approaches may be a result of the students trying to make sense of the technology in the given setting, and that they are responding to what they comprehend as the most important task and what is expected of them. Making the bars low may have been seen by Thumbs Up as the most important task in excerpt TU3d, which for them may have been equal to designing a CO2 friendly house. The two groups made different use of SCY-Lab, and it functioned as support for their work in different ways.

As we have seen earlier, the two student groups had different approaches as they shared their expert knowledge. In addition to how the students talked about scientific concepts and phenomena, they used mediating artefacts such as models in different ways. Linda in Power Puff had solar cells as her field of expertise, and was explaining the photoelectric effect in solar panels to the other students in excerpt PP1a. As she was presenting, Claire said explicitly that she did not understand. Linda tried different strategies in order to make her explanation understandable, and introduced a model of a solar panel on her laptop. When Claire discovered the model, the interaction took another direction. The students used the model as a resource in order to make sense of the topic, and related it to something they already knew; an electric car. This way, it is possible to say that the model of the solar panel became a productive resource for the students in their sense making of complex scientific phenomena. Jane in Thumbs Up had energy sources as her field of expertise, and talked about wind power and wind mills in excerpt TU1b. At a point in her presentation, she introduced a model where they could see where the wave potential was. Tom responded to her statement, concerning the location of the wave potential. However, the introduction of the model did not take the interaction into a different turn, in a way that the other students explicitly used the model in their sense making of the scientific concept Jane was presenting.

The findings discussed in this section of the chapter show that the students used the mediating artefacts in different ways in their collaboration and sense making. It is possible to argue that the students in Power Puff used artefacts in a productive way in their sense making, to a larger degree than Thumbs Up did.

6.3 Collaborating within the institutional setting of school

The students' collaboration and meaning making process does not happen in a vacuum. Their activities are situated within a social and institutional context, namely the context of school. This institutional setting is according to the sociocultural perspective a central aspect of the students' meaning making process, as they are negotiating and making sense of its expectations, norms and values.

Säljö (2004) argues that actions and practice constitutes each other. Individuals ascribe meaning to a context, and regulate actions accordingly, based on the assumptions of what is expected in that given context. Thus, students have to interpret and make sense of the social context, expectations and norms, and they have to decide how to respond (Furberg, 2009; Furberg & Ludvigsen, 2007). However, the expectations and norms may not be expressed explicitly, so it is up to the students to make sense of how to act and relate to the given context.

I have already argued that the two groups of students seemed to have somewhat different orientations during their work with the project: Power Puff was mostly conceptually oriented compared to Thumbs Up, who was mostly procedurally oriented. Nevertheless, the analysis show that the two groups of students became more alike in the second last part of the project, as Power Puff's orientation seemed to change towards being more procedural. This can be seen in excerpts PP4a and PP4b, where the students for the first time during the project were being explicit about the expectations and requirements within the setting, and they were adjusting to these. They addressed the expectations and requirements in their discussion about the presentation and how they would be assessed. The students were focused on their end products and to get the tasks done. In contrast to earlier in the project, they divided the tasks between them, instead of working collaboratively.

These findings match with those of Furberg and Ludvigsen (2008), where the students' orientations changed during the learning sequence, towards becoming more procedural oriented in the second last part of the project. Furberg and Ludvigsen (2008) argue that is the institutional norms, expectations and values that change this orientation. This can be seen in relation to the findings in my study, where the students as they moved into the second last part of the project had to make sense of the task to write up their end product. It is possible to assume that the students in Power Puff became more procedural at the end, because they became more attuned towards the expectations and requirements within the institutional setting of school. It may have been that the expectations and requirements were more visible

to the students in the second last part of the project, than in the earlier parts. This may be because the second last part was about making more tangible products, like a presentation and a written report. During the earlier parts of the projects, the expectations and requirements may have been more concealed, and the students had to make sense of these on their own, and decide how to respond. Due to this, the students' different orientations during the largest part of the project may be products of them making sense of the expectations and requirements in different ways, and adjusting thereafter. Krange and Ludvigsen (2008) argue that in their study, the school as curriculum deliverer partly hindered rather than stimulated the students' knowledge making in science education. It may be reasonable to argue that the students orientations may indirectly say something about what is actually seen as valuable in the setting they are in.

Even though the two student groups had different approaches when collaborating and working with the three first parts of the project, the students' textual end products showed that their presentations and reports were quite similar regarding the content. The students in both groups were given the same grade as an evaluation of their work with the project, namely the top grade 6. The students were evaluated based on their end product, and not on the process of work they had gone through. On the other side, even though the students collaborated and worked with the project in different ways, they may have had somewhat the same comprehension of the expectations and requirements within the institutional setting of school, and their adjustment to this resulted in the same top grade. Furberg and Ludvigsen (2008) points out the importance of being sensitive to how students orient their talk and activity towards the values, demands and expectations in the institutional setting of school. It is reasonable to argue that the students in my study ended up with the same orientations due to their comprehension of the what is expected of them in the setting they were in, namely to finish their end product.

I have now discussed the findings from my empirical study, focusing on the similarities and differences in the two group's way of collaborating when engaging with the computer-based inquiry environment SCY-Lab. I have elucidated my findings using theory which is presented earlier in this thesis, together with relevant findings from the studies presented in my review.

7 Implications and concluding remarks

In this concluding part of the thesis, a presentation of the research conducted will be given. Firstly, I will give a brief outline of the theory which this thesis is framed within. Secondly, I will present my research questions and sum up the findings from the empirical study. Thirdly, I will sketch some possible implications of my findings, and how they can be seen in relation to challenges related to support of students' collaboration and design in CSCL settings.

This thesis is framed within the sociocultural perspective, where learning is seen as an interactive meaning making process, where people learn as they interact with others and the artefacts in their surroundings. According to this perspective, one cannot understand learning without taking learners' interaction with each other, their interaction with cultural artefacts and the social context into account (Säljö, 2004). The dialogical research approach has been used in this thesis, as this is line with the sociocultural perspective, and makes the interaction, artefacts and institutional practices available for study (Arnseth & Ludvigsen, 2006). Within this approach, the unit of analysis is individuals' interaction with each other, with focus on how meanings, tools and knowledge are constituted in social practices (Säljö, 2004). Arnseth & Ludvigsen (2006) argue that it is social interaction that meanings and effects of CSCL tools become available for study. As the analytic practice within the dialogical approach is concerned with the sequential unfolding of activities along different time scales, I found this approach most fruitful for my empirical study on students working collaboratively with the computer-based inquiry environment SCY-Lab.

The analytic procedures conducted in this thesis is interaction analysis, where an underlying assumption is that action and knowledge are social in origin, and situated in practices and contexts (Jordan & Henderson, 1995). Interaction analysis has made it possible for me to get access to where the collaboration takes place, together with the mediating artefacts in the given context. Analytically, I have used the concept of "interaction trajectory", which refers to actions that happen over a period of time. This is based on the work by Dreier (1999), Lave (1997) Mercer (2000), (as cited in Furberg & Ludvigsen, 2008). In the analysis, I have followed the process of the two groups Power Puff and Thumbs Up, with focus on their collaboration, interaction and meaning making process.

The focus of this thesis is to explore students' collaboration when engaging with a computer-based inquiry environment. My three research questions are as follows:

1. *What characterizes the students' collaboration as they engage with the computer-based inquiry environment SCY-Lab?*
2. *How is the computer environment, as well as other digital tools functioning as structuring resources in the students' collaboration?*
3. *How is the institutional setting functioning as a structuring resource for the students' collaboration?*

The main aim with this thesis is to contribute to the understanding of students' collaboration as they engage with computer-based inquiry environments in the setting of school. My research questions also cover the aspects of how technology and the institutional setting are structuring the students' collaboration.

In relation to what characterizes the students' collaboration as they engage with SCY-Lab, my findings show that the two groups of students differed in how they made decisions, what these decisions were based on, and how they talked about scientific concepts and phenomena. More specific, the groups differed in to what extent decisions were made jointly and whether they brought in resources from outside the learning environment or not, in order to gain more information and to make decisions. When discussing scientific concepts and phenomena, the groups were different in how they invited each other into the conversation and being explicit about whether they understood the topics, or not. As argued in my discussion, Power Puff was closer to what Mercer & Wegerif (2009) term as exploratory talk in their sharing of expert knowledge, than Thumbs Up. Thumbs Up's talk when discussing scientific concepts and phenomena had more resemblance with what Mercer & Wegerif (2009) term as cumulative talk, in addition to disputational talk. Based on the findings presented above, it is possible to say that the two groups had different orientations during the project. Through most of the project, the students in Thumbs Up seemed to be mostly procedurally oriented, as they were focused on being time efficient and to move on with their tasks. Overall, the students in Power Puff were being more oriented towards the conceptual compared to the students in Thumbs Up. However, in the last phase of the project, the groups became more similar, as Power Puff's orientation changed towards being more procedural.

With regard to how the technology was functioning as a structuring resource for the students' collaboration, I also found some differences between the two groups. The main difference was related to the two groups' comprehension of SCY-Lab. Power Puff may have seen SCY-Lab as an open resource, where they had to obtain more information from outside SCY-Lab in order to gain a better understanding and to make decisions. However, the students in Thumbs Up may have seen SCY-Lab as a more complete resource, where the combination of the information provided and their own opinions and experiences were all they needed in order to understand and to make decisions. Also, the two groups differed in how they used mediating artefacts such as models in their sharing of expert knowledge, and how these models structured their interactions concerning rather complex scientific phenomena.

Concerning how the institutional setting structured the students' collaboration, my findings show that the students' orientations became more alike in the second last part of the project, as Power Puff's orientation seemed to change towards being more procedural. It is possible to assume that this is because they became more attuned towards the expectations and requirements within the institutional setting of school as they entered the second last part of the project. In this way the institutional setting of school, structured the students' collaboration.

In the following, I will sketch some possible implications of my findings and how they can be seen in relation to challenges related to support of students' collaboration and design in CSCL settings. I will consider the role of the teacher, the assessment form, and how students could be supported in their collaboration process.

Earlier studies have shown that the role of the teacher is important for students working with scientific learning environments, in order to support the students in their meaning making process and to be more oriented towards the knowledge domain (Krange & Ludvigsen, 2008; Furberg & Rasmussen, in press). Students working with computer-based inquiry environments need support in order to understand how to relate to the knowledge domain and to understand what is expected of them during the work with the project, not just the end products. This is in line with the findings from my study, where the students' different orientations during the project may have been a result of them being on their own when making sense of expectations and requirements on how to carry out the project work. Related to this, it is possible to argue that the teacher could play an important role in order to guide the

students in their sense making of the expectations and requirements, as well as the technology and provided mission.

The students in the conducted empirical study were assessed on their end products, and not on the process of collaborating and carrying out the project. This can be seen in relation to the distinction between summative and formative evaluation, done by Scriven (1991). Summative evaluation is an evaluation of the result, without the focus on improvement, and formative evaluation is intended to support the process of improvement (Scriven, 1991, pp. 20). It is possible to argue that in order to get students to collaborate and be focused towards the knowledge domain during the project work; they should also be assessed on their process of working together. The findings in my study indicate that in this project, being oriented towards the procedural was enough to achieve a good grade. At the same time, being oriented towards the knowledge domain during the project work was not necessary in order to achieve the same grade. With other words, the teacher did not discover the differences in the ways the students in my study worked with the project. As Krange and Ludvigsen (2008) argue, the students may have solved the task, but it is not given that they understand how the knowledge domain and scientific concepts are parts of a larger conceptual problem. In order to gain information about the students' actual understanding of the knowledge domain, it may be necessary to also assess the students during their work and collaboration with the given project.

My findings imply that students working collaboratively when engaging with computer-based inquiry environments may need different kind of support in the collaboration process. One way of providing this support could be by integrating prompts in the provided technology. Kollar et al. (2007) found that students receiving collaboration support embedded in the learning environment, gained better collaboration skills. Furthermore, Bell and Linn (2000) argue that students can be supported in their scientific inquiry process by making arguments visible for them. The authors found that supporting students in constructing arguments elicited knowledge integration and enhanced their understanding of the nature of science. Manlove et al. (2006) found that students, who received support for regulation during collaborative learning embedded in the learning environment, performed increased planning activities. These studies all show positive effects on supporting students in their collaboration process. Based on this, is it possible to argue in favour of embedding support for the collaboration process in SCY-Lab.

Mercer et al. (2004) argue that using "ground rules" in order to generate talk with elements of exploratory talk can represent a kind of freedom for students, as the social status of individuals may be neutralized and making the learning environment more fair for everyone to contribute. Inspired by the ground rules for exploratory talk introduced by Mercer and Wegerif (1999) and used in a study by Mercer et al. (2004), it is possible that students would benefit from agreeing on, and using ground rules for collaboration. The teacher could function as a support for the students in order to follow the ground rules for collaboration.

Further research is suggested as this is a large and complex field. As the students in my empirical study were high achieving students, it would be necessary to conduct further research with students at other levels. As I have pointed out earlier in this thesis, students' learning does not happen in a vacuum. In order to understand learning, it is crucial to also take the technology and the institutional settings with its norms, values and expectations into account. As discussed in this thesis, the sociocultural perspective on learning implies a focus on the interaction, the mediating artefacts and the institutional setting in order to understand learning. Students are making sense of scientific concepts and phenomena in interaction and collaboration with each other, and thinking is made visible through talk and interaction. Meanings and interpretations of words and concepts are negotiated, and language is a crucial tool for this interaction. Seeing my findings in relation to the ideals in the sociocultural perspective, it may be possible to suggest that computer-based inquiry environments should be designed in order to support collaborative activities such as thinking together and negotiating a shared meaning of scientific words and concepts.

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